NASA Technical Memorandum TM 107562

Debris/Ice/TPS Assessment and Integrated Photographic Analysis for Shuttle Mission STS-57

July 1993

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DEBRIS/ICE/TPS ASSESSMENT
AND
PHOTOGRAPHIC ANALYSIS
OF
SHUTTLE MISSION STS-57

June 21, 1993

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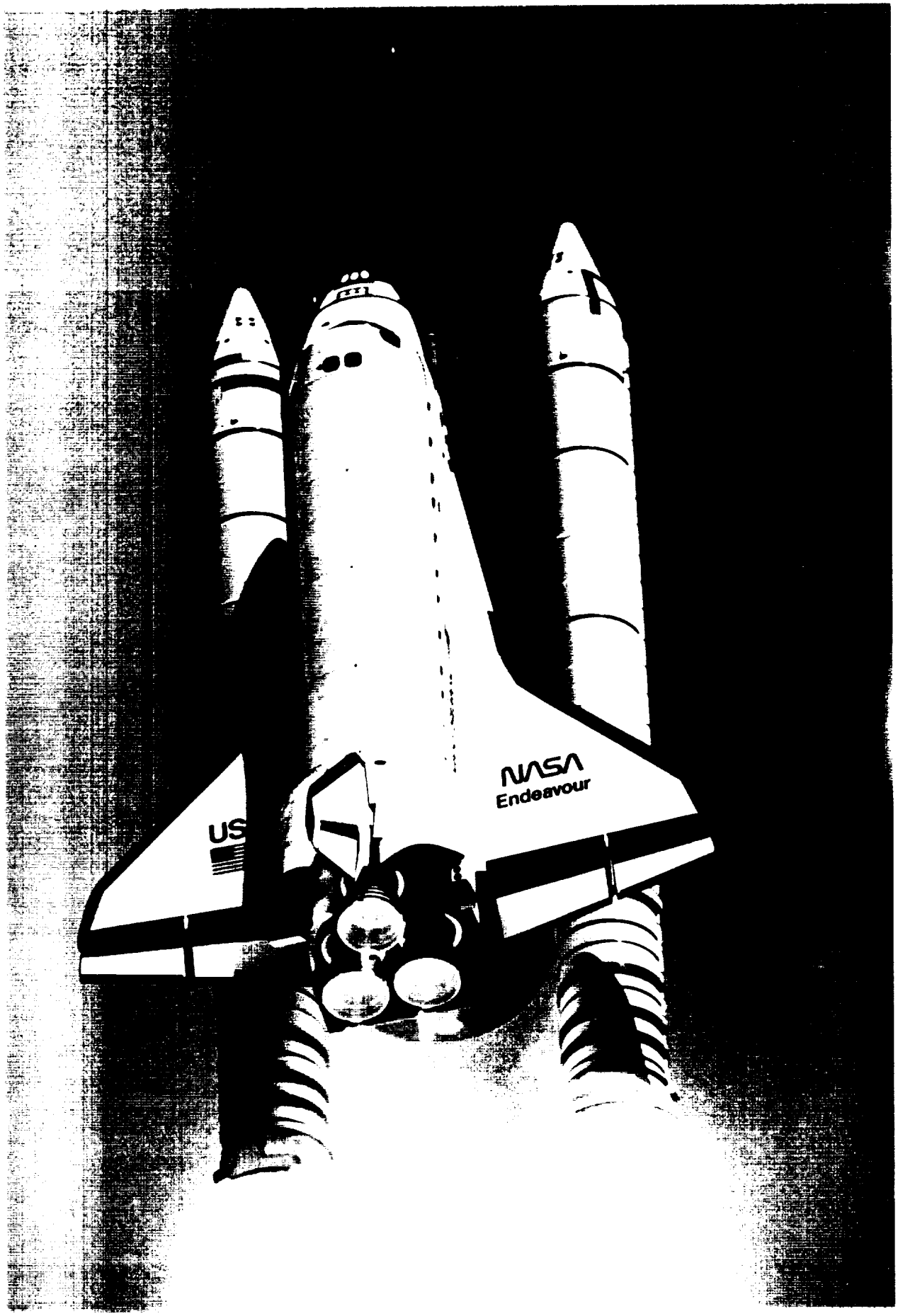
TABLE OF CONTENTS



ORIGINAL PAGE
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Shuttle Mission STS-57 was launched at 9:07 a.m. local 6/21/93

1.0 Summary

A pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 19 June 1993. The detailed walkdown of Launch Pad 39B and MLP-2 also included the primary flight elements OV-105 Endeavour (4th flight), ET-58 (LWT 51), and BI-059 SRB's. There were no vehicle anomalies.

The vehicle was cryoloaded for flight on 20 June 1993. There were no Launch Commit Criteria, OMRS, or NSTS-08303 criteria violations. There were no ice/frost conditions outside of the established data base. The External Tank exhibited light condensate on the TPS acreage. The LH2 ET/ORB umbilical leak sensor detected no significant hydrogen leakage during the cryoload. No unusual vapors or cryogenic drips were visible during tanking, stable replenish, and launch.

The launch was scrubbed at T-5 minutes (and holding) due to RTLS and TAL weather. A post drain inspection of the vehicle revealed no significant anomalies and the ET appeared ready for the next cryoload.

A repeat of the pre-launch debris inspection had not been planned since the MLP deck was subject to controlled access.

The vehicle was cryoloaded a second time on 21 June 1993. There were no Launch Commit Criteria, OMRS, or NSTS-08303 criteria violations. There were no ice/frost conditions outside of the established data base. The External Tank exhibited light condensate on the TPS acreage. No unusual vapors or cryogenic drips were visible during tanking, stable replenish, and launch.

After the 9:07 a.m. launch on 21 June 1993, a debris inspection of Pad 39A was performed. No flight hardware or TPS materials were found with the exception of a frangible nut web on the stud in holddown post (HDP) #2. EPON shim material on the south holddown posts was intact. There was no visual indication of a stud hang-up on any of the south holddown posts. No frangible nut/ordnance fragments were found. Damage to the facility overall was minimal.

A total of 133 films and videos were analyzed as part of the post launch data review. No major vehicle damage or lost flight hardware was observed that would have affected the mission. No stud hang-ups occurred on any of the holddown posts. Two frangible nut pieces fell from the HDP #2 DCS/stud hole after liftoff. All T-0 umbilicals operated properly.

On-orbit imagery, ET/ORB umbilical cameras and the flight crew handheld photography, revealed nominal SRB and ET separations. The lightning contact strip was missing from the top of the LO2 ET/ORB umbilical (the others were intact). TPS damage had occurred on the top inboard section of the umbilical.

A walkdown of KSC Runway 33 was performed immediately after landing. No debris or unexpected flight hardware was found. All drag chute hardware was recovered and appeared to be in good condition.

Orbiter post landing microchemical sample results revealed a variety of residuals in the Orbiter window samples from sources such as Orbiter TPS, SRB BSM exhaust residue, window covers and processing, natural landing site products, organics, and paint. These residual sampling data do not indicate a single source of damaging debris since no damage has been associated with the sampled material. Additionally, most of the observed materials have previously been documented in post-landing sample reports. The residual sample data also showed no debris trends when compared to previous mission data.

A total of 17 Post Launch Anomalies, including six IFA candidates, were observed during the STS-57 mission assessment.

2.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

A pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 19 June 1993 from 0910 - 1050 hours. The detailed walkdown of Launch Pad 39B and MLP-2 also included the primary flight elements OV-105 Endeavour (4th flight), ET-58 (LWT 51), and BI-059 SRB's. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and vehicle configuration changes.

There were no significant vehicle anomalies or debris issues. A Problem Report was taken to document damaged foam on the ET helium inject box. The PR was subsequently dispositioned to accept the condition for flight.

Four each composite material samples were U-bolted to the hand rails on the FSS 135, 175, 215, and 255 foot levels (east side). The Debris Team evaluated each installation and found no debris concerns.

Two items were entered in S0007, Appendix K: 1) a loose cable tray clamp on the FSS 255 foot level; 2) loose bolts and one missing nut under the MLP zero level raised decks around the SRB exhaust holes.

The MLP deck and areas under the raised deck were swept/vacuumed again prior to launch to remove small debris items, such as sand, rust flakes, and paint chips.

Four each composite material samples were U-bolted to the hand rails on four levels of the FSS east side

3.0 SCRUB

The launch of STS-57 was scrubbed at T-5 minutes and holding due to RTLS and TAL site weather.

3.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 20 June 1993 from 0420 to 0550 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria, OMRS, or NSTS-08303 violations. There were no conditions outside of the established data base. Ambient weather conditions at the time of the inspection were:

Temperature:	75.7 Degrees F
Relative Humidity:	71.1 Percent
Wind Speed:	6.29 Knots
Wind Direction:	117 Degrees

A portable Shuttle Thermal Imager (STI) infrared scanning radiometer was utilized to obtain vehicle surface temperature measurements for an overall thermal assessment of the vehicle, as shown in Figures 1 and 2.

3.2 ORBITER

No Orbiter RCC panel or TPS anomalies were observed. All RCS thruster paper covers were intact, though the R4U and L2U covers had been wetted by vapors inside the thrusters. Less than usual ice/frost accumulations were present at the SSME #1 and #2 heat shield-to-nozzle interfaces. The base heat shield tiles were dry. An infrared scan revealed no unusual temperature gradients on the base heat shield or engine mounted heat shields. No unusual vapors originated from inside the SSME nozzles.

3.3 SOLID ROCKET BOOSTERS

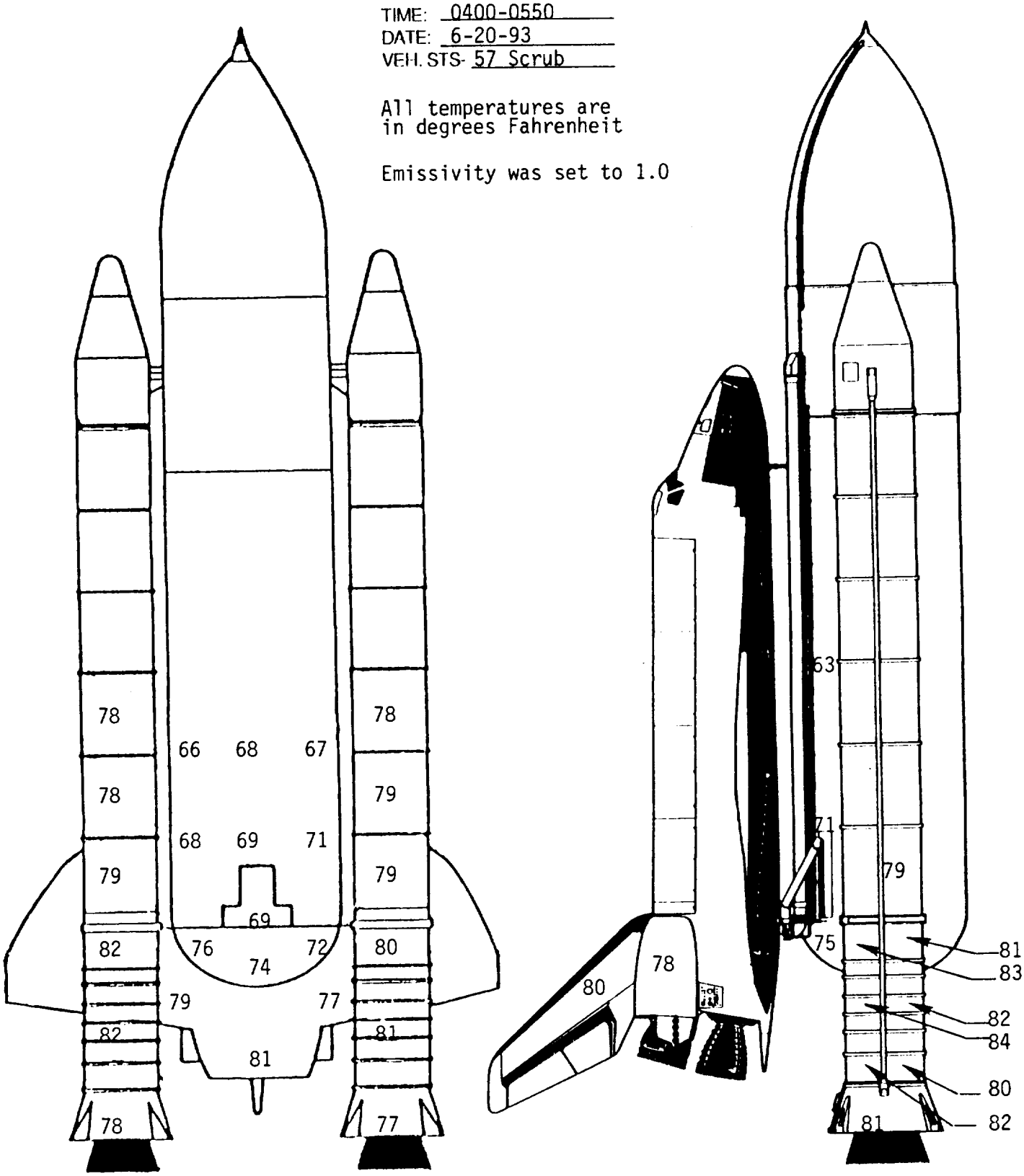
No SRB anomalies or loose ablator/cork were observed. The STI portable infrared scanner recorded RH and LH SRB case temperatures between 78 and 80 degrees Fahrenheit (F). In comparison, temperatures measured by a hand-held Minolta/Land Cyclops spot radiometer ranged from 76 to 79 degrees F and the SRB Ground Environment Instrumentation (GEI) measured temperatures of 79-80 degrees F. All measured temperatures were above the 34 degrees F minimum requirement. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 79 degrees F, which was within the required range of 44-86 degrees F.

Figure 2. **SSV INFRARED SCANNER SURFACE TEMPERATURE SUMMARY DATA**

TIME: 0400-0550
DATE: 6-20-93
VEH. STS- 57 Scrub

All temperatures are in degrees Fahrenheit

Emissivity was set to 1.0

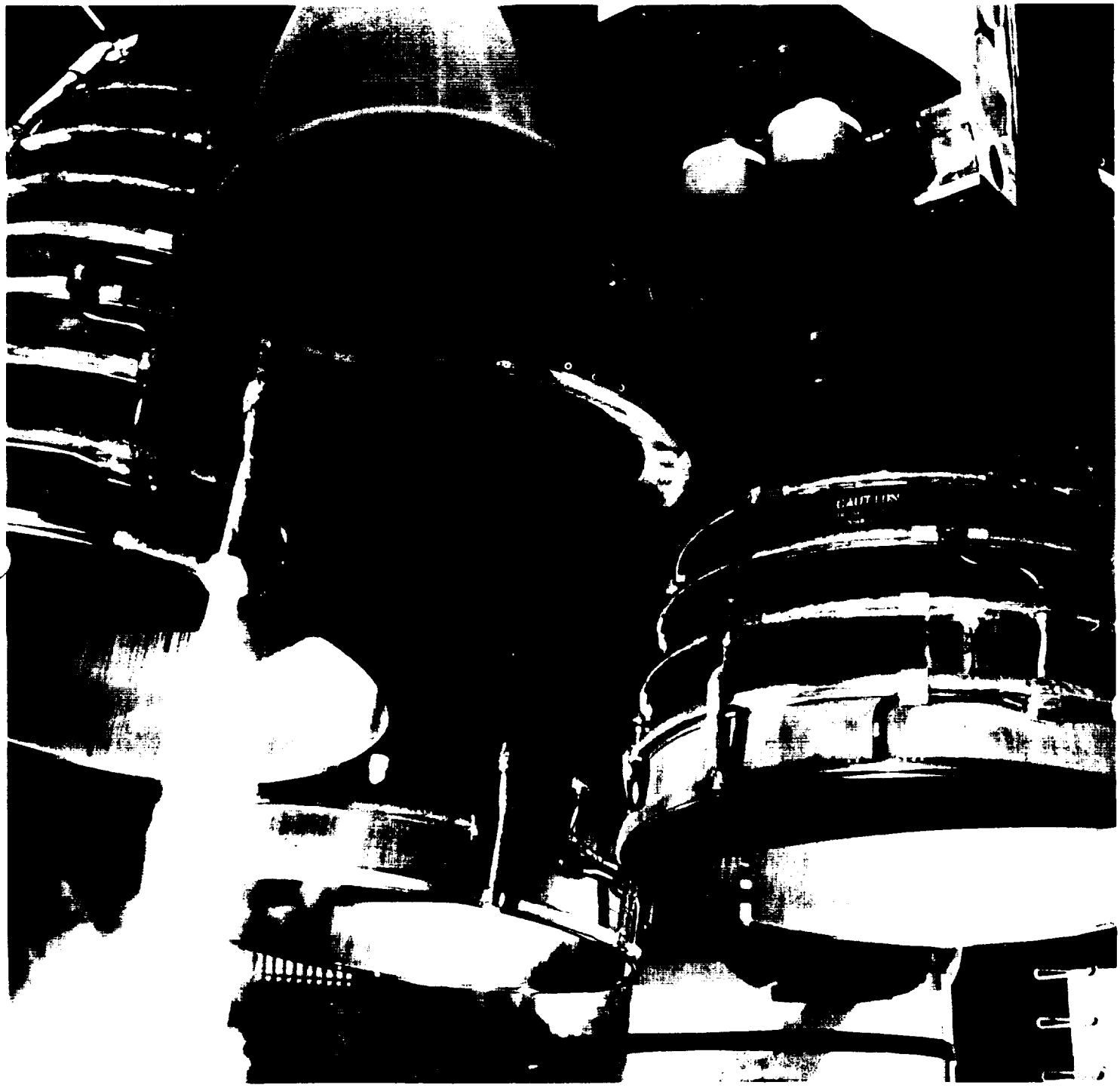


EGG/V-343C

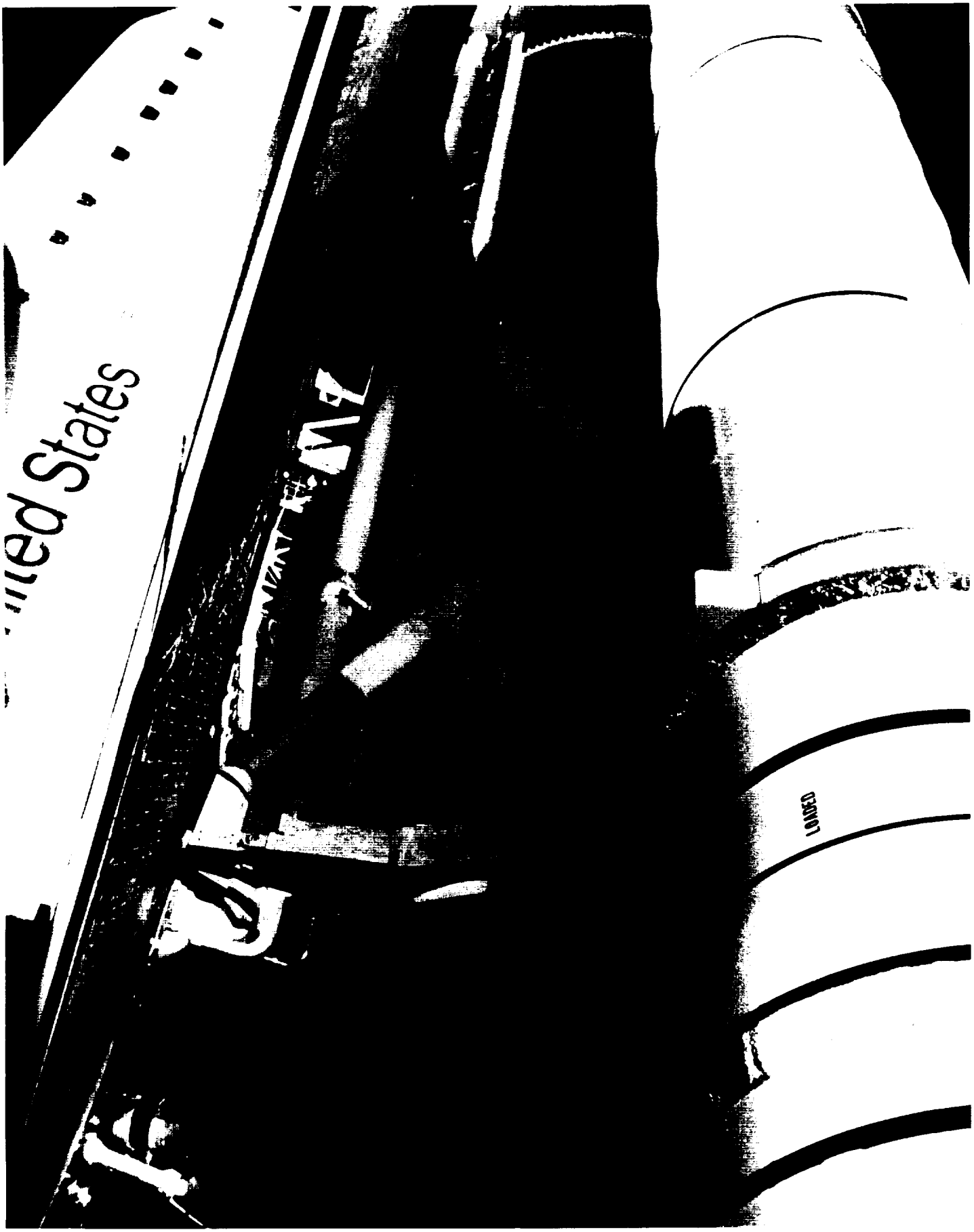
STS- 57	TEST S0007 SCRUB - RTLS Weather																										DATE: 20 June 1993		T-0 TIME: DATE:		NASA KSC Ice/Frost/Debris Team
ORBITER 105	ET 58	SRB BI-59	MLP 2	PAD B	LO2 CHILLDOWN TIME: 00:57 SLOW FILL TIME: 01:32						FAST FILL TIME: 01:43 REPLENISH TIME: 03:48						LH2 CHILLDOWN TIME: 00:57 SLOW FILL TIME: 01:00						FAST FILL TIME: 01:47 REPLENISH TIME: 03:40								
TIME (EDT)	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058								
	TEMP F	REL HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR					
0115	77.40	68.2	66.54	7	104	II	4.13	63.61	0.0013	-0.1658	II	4.13	58.91	0.0031	-0.1357	II	3.85	57.39	0.0034	-0.1211	II	8.54	63.07	0.0029	-0.2689					
0130	77.40	58.6	62.30	6	97	II	3.54	60.35	0.0007	-0.1310	II	3.54	54.99	0.0023	-0.1021	II	3.30	53.31	0.0026	-0.0898	II	7.32	59.46	0.0018	-0.2047					
0145	77.80	67.4	66.60	9	100	II	5.31	64.53	0.0010	-0.2059	II	5.31	60.96	0.0030	-0.1750	II	4.95	59.70	0.0034	-0.1580	II	10.98	64.52	0.0022	-0.3464					
0200	77.20	67.8	66.18	7	103	II	4.13	63.29	0.0013	-0.1637	II	4.13	58.56	0.0031	-0.1336	II	3.85	57.06	0.0034	-0.1192	II	8.54	62.76	0.0028	-0.2654					
0215	77.40	68.2	66.54	8	103	II	4.72	64.17	0.0012	-0.1851	II	4.72	59.92	0.0031	-0.1546	II	4.40	58.52	0.0035	-0.1389	II	9.76	63.77	0.0026	-0.3065					
0230	77.20	68.6	66.51	8	103	II	4.72	64.06	0.0013	-0.1844	II	4.72	59.80	0.0031	-0.1539	II	4.40	58.41	0.0035	-0.1382	II	9.76	63.67	0.0027	-0.3053					
0245	77.60	68.6	66.90	8	99	II	4.72	64.48	0.0013	-0.1875	II	4.72	60.24	0.0032	-0.1569	II	4.40	58.86	0.0035	-0.1410	II	9.76	64.09	0.0027	-0.3105					
0300	77.60	67.8	66.57	8	100	II	4.72	64.27	0.0012	-0.1859	II	4.72	60.03	0.0031	-0.1553	II	4.40	58.64	0.0034	-0.1396	II	9.76	63.87	0.0026	-0.3077					
0315	77.40	68.2	66.54	7	102	II	4.13	63.61	0.0013	-0.1658	II	4.13	58.91	0.0031	-0.1357	II	3.85	57.39	0.0034	-0.1211	II	8.54	63.07	0.0029	-0.2689					
0330	77.40	68.6	66.71	6	106	II	3.54	63.02	0.0015	-0.1468	II	3.54	57.75	0.0032	-0.1171	II	3.30	56.09	0.0034	-0.1038	II	7.32	62.29	0.0032	-0.2322					
0345	76.80	69.6	66.53	7	100	II	4.13	63.34	0.0015	-0.1640	II	4.13	58.61	0.0032	-0.1339	II	3.85	57.07	0.0035	-0.1194	II	8.54	62.83	0.0031	-0.2963					
0400	78.00	69.8	67.78	8	90	II	4.72	65.21	0.0014	-0.1930	II	4.72	61.01	0.0033	-0.1622	II	4.40	59.64	0.0036	-0.1461	II	9.76	64.83	0.0029	-0.3201					
0415	77.20	70.2	67.16	9	114	II	5.31	64.94	0.0013	-0.2068	II	5.31	61.06	0.0033	-0.1759	II	2.89	54.94	0.0036	-0.0908	II	12.51	66.24	0.0024	-0.3960					
0430	76.00	70.2	65.98	6	114	II	3.54	61.92	0.0016	-0.1404	II	3.54	56.59	0.0032	-0.1109	II	1.98	48.04	0.0031	-0.0626	II	8.34	62.02	0.0032	-0.2529					
0445	75.80	70.4	65.87	7	120	II	4.13	62.48	0.0015	-0.1584	II	4.13	57.70	0.0032	-0.1285	II	2.24	50.62	0.0032	-0.0827	II	9.73	62.68	0.0028	-0.2926					
0500	75.20	71.0	66.51	6	120	II	3.54	61.28	0.0016	-0.1368	II	3.54	55.88	0.0032	-0.1071	II	1.92	48.25	0.0031	-0.0582	II	8.34	61.36	0.0032	-0.2462					
0515	75.40	71.2	65.79	6	120	II	2.95	60.60	0.0017	-0.1191	II	2.95	54.52	0.0032	-0.0900	II	1.60	46.03	0.0030	-0.0604	II	6.95	60.53	0.0035	-0.2075					
0530	74.80	72.2	65.39	5	110	II	2.95	59.96	0.0017	-0.1159	II	2.95	53.84	0.0032	-0.0868	II	2.75	51.86	0.0034	-0.0751	II	6.10	58.09	0.0036	-0.1769					
0545	74.60	72.8	65.63	5	120	II	2.95	60.11	0.0018	-0.1166	II	2.95	53.99	0.0033	-0.0876	II	1.60	47.39	0.0031	-0.0576	II	6.95	60.08	0.0036	-0.2036					
0600	75.00	73.4	66.25	6	107	II	3.54	61.63	0.0018	-0.1388	II	3.54	56.26	0.0034	-0.1093	II	3.30	54.54	0.0037	-0.0961	II	7.32	61.01	0.0037	-0.2201					
0615	75.20	73.6	66.52	8	94	II	4.72	63.22	0.0017	-0.1784	II	4.72	58.92	0.0035	-0.1480	II	4.40	57.48	0.0038	-0.1324	II	9.76	62.92	0.0034	-0.2964					
0630	76.00	72.6	66.93	8	97	II	4.72	63.82	0.0016	-0.1828	II	4.72	59.55	0.0035	-0.1522	II	4.40	58.13	0.0038	-0.1365	II	9.76	63.50	0.0033	-0.3035					
0645	77.60	71.4	68.03	7	96	II	4.13	64.65	0.0016	-0.1729	II	4.13	59.99	0.0034	-0.1425	II	3.85	58.47	0.0038	-0.1275	II	8.54	64.16	0.0034	-0.2814					
0700	78.00	69.6	67.70	8	92	II	4.72	65.16	0.0014	-0.1926	II	4.72	60.96	0.0033	-0.1618	II	4.40	59.59	0.0036	-0.1457	II	9.76	64.77	0.0029	-0.3194					
0715	78.20	69.2	67.74	9	86	II	5.31	65.72	0.0012	-0.2133	II	5.31	61.90	0.0032	-0.1821	II	4.95	60.63	0.0036	-0.1647	II	10.98	65.42	0.0026	-0.3594					
0730	78.40	68.2	67.52	7	84	II	4.13	64.66	0.0014	-0.1729	II	4.13	60.02	0.0032	-0.1426	II	3.85	58.52	0.0035	-0.1277	II	8.54	64.12	0.0029	-0.2807					
0745	78.20	68.8	67.57	9	86	II	5.31	65.61	0.0012	-0.2124	II	5.31	61.78	0.0032	-0.1813	II	4.95	60.52	0.0035	-0.1639	II	10.98	65.31	0.0025	-0.3578					
0800	78.40	68.4	67.61	10	95	II	5.90	66.09	0.0010	-0.2329	II	5.90	62.59	0.0030	-0.2014	II	5.50	61.41	0.0035	-0.1828	II	12.20	65.86	0.0022	-0.3976					
0815	78.40	68.6	67.69	11	94	II	6.49	66.47	0.0009	-0.2530	II	6.49	63.22	0.0030	-0.2212	II	6.05	62.13	0.0034	-0.2013	II	13.42	66.29	0.0019	-0.4370					
0830	78.60	68.2	67.72	7	98	II	4.13	64.87	0.0014	-0.1743	II	4.13	60.24	0.0032	-0.1439	II	3.85	58.74	0.0035	-0.1290	II	8.54	64.33	0.0030	-0.2831					
0845	78.60	68.2	67.72	8	87	II	4.72	65.42	0.0012	-0.1945	II	4.72	61.23	0.0032	-0.1637	II	4.40	59.86	0.0035	-0.1475	II	9.76	65.01	0.0027	-0.3222					
0900	79.20	65.6	67.21	10	104	II	5.90	66.15	0.0007	-0.2333	II	5.90	62.64	0.0028	-0.2018	II	5.50	61.50	0.0032	-0.1833	II	12.20	65.88	0.0016	-0.3976					
0915	79.20	65.0	66.96	10	112	II	5.90	65.99	0.0006	-0.2318	II	5.90	62.47	0.0027	-0.2004	II	5.50	61.33	0.0031	-0.1819	II	12.20	65.70	0.0015	-0.3948					
0930	79.60	64.2	67.00	9	107	II	6.31	65.80	0.0007	-0.2137	II	5.31	62.00	0.0027	-0.1827	II	4.95	60.76	0.0031	-0.1654	II	10.98	65.43	0.0017	-0.359					
0945	79.60	63.0	66.47	8	119	II	4.72	65.04	0.0008	-0.1914	II	4.72	60.84	0.0027	-0.1606	II	2.56	54.59	0.0030	-0.0836	II	11.12	65.14	0.0015	-0.3582					
1000	80.00	63.6	67.12	9	121	II	5.31	66.04	0.0008	-0.2157	II	5.31	62.25	0.0026	-0.1846	II	2.88	56.39	0.0031	-0.0974	II	12.51	66.20	0.0012	-0.4106					
1015	79.80	62.0	66.21	9	103	II	5.31	65.39	0.0005	-0.2102	II	5.31	61.57	0.0025	-0.1793	II	4.95	60.33	0.0029	-0.1623	II	10.98	64.99	0.0013	-0.3524					
1030	80.20	61.8	66.51	10	109	II	5.90	66.10	0.0003	-0.2326	II	5.90	62.60	0.0023	-0.2012	II	5.50	61.46	0.0028	-0.1829	II	12.20	65.77	0.0009	-0.3954					
AVG.	77.53	68.28	66.67	7.76	E		4.61	64.04				4.58	59.59				3.94	57.07				9.72	63.71							

Period of Ice Team Inspection

Figure 3. "SURFICE" Computer Predictions



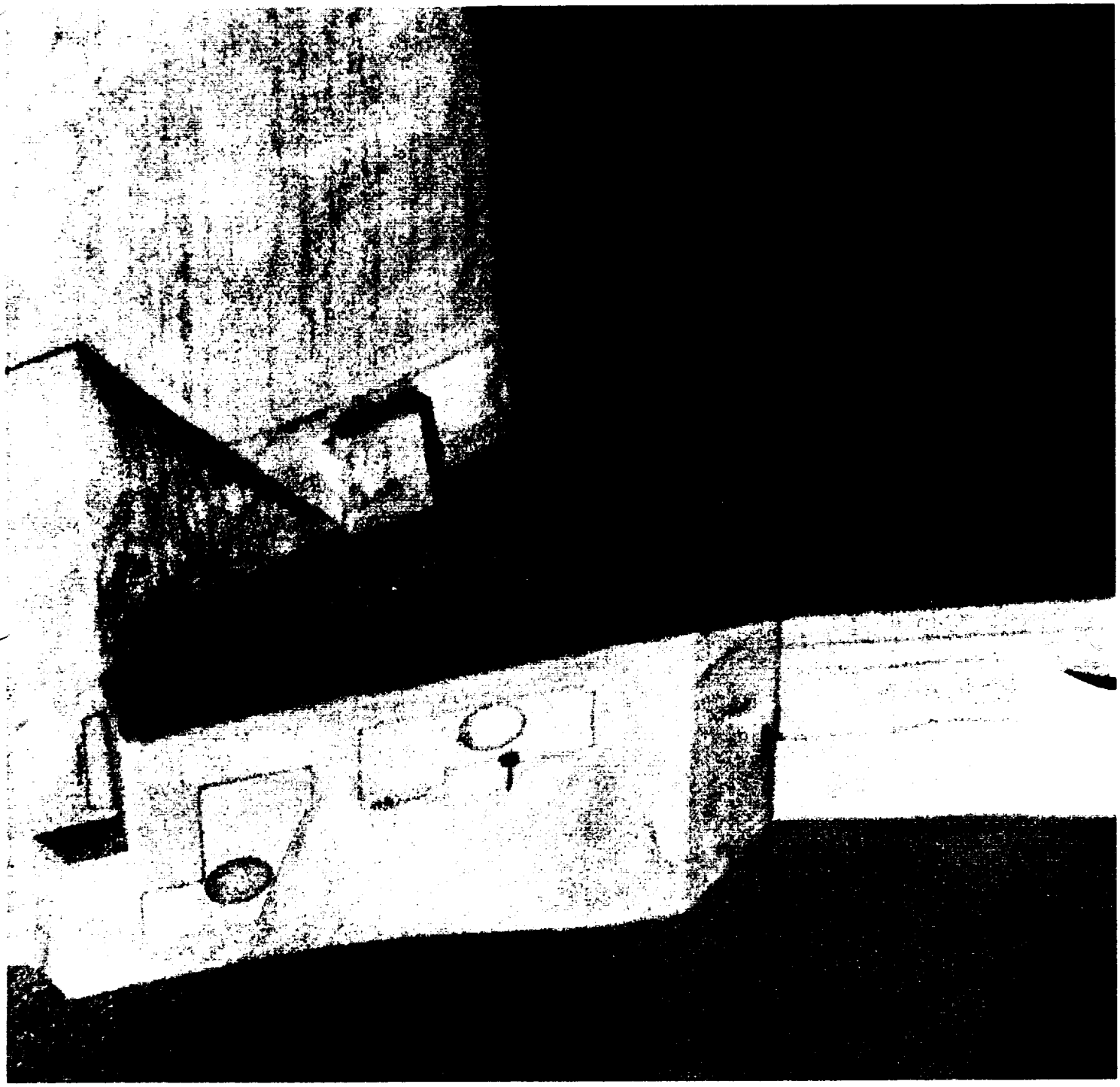
Overall view of the Shuttle main engines



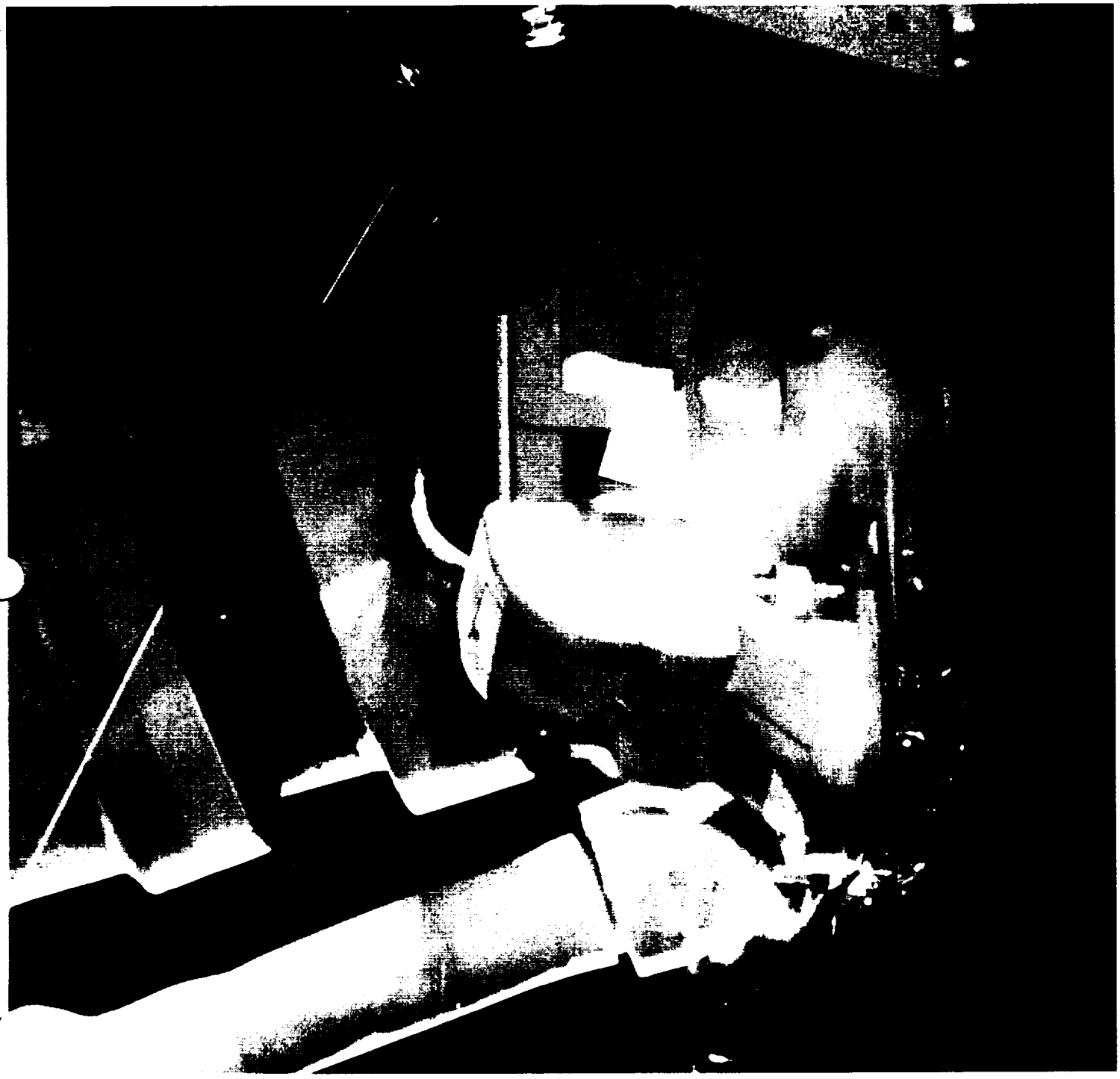
Condensate, but no ice or frost, was present on the LH2 tank acreage. There were no acreage TPS anomalies.

ORIGINAL PAGE
COLOR PHOTOGRAPH

Ice/frost accumulations in the LO2 feedline bellows and support brackets was typical



An 8-inch long by 3/8-inch wide crack occurred in the -Y vertical strut cable tray forward surface TPS near the longeron closeout interface. The crack exhibited no offset and was not filled with ice or frost. The presence of the crack was acceptable for flight per the NSTS-08303 criteria.



Less than usual amounts of ice/frost had formed on the ET/ORB LH2 umbilical. No cryogenic drips or unusual vapors appeared during tanking, stable replenish, and launch.

3.6 POST DRAIN VEHICLE INSPECTION

The launch of STS-57 was scrubbed at T-5 minutes and holding due to RTLS and TAL site weather. A post drain inspection of the vehicle was performed at Pad-39B on 20 June 1993 from 1730 to 1845 hours.

There were no anomalies on the Orbiter, Solid Rocker Boosters, or launch pad/facility.

There was no visible damage on the External Tank nosecone or fairing. Three small areas of topcoat were missing from the -Y footprint area. The +Y footprint area was not accessible for inspection. The tumble valve cover was intact.

No anomalies (divots or cracks) were observed on the LO2 tank, intertank, or LH2 tank acreage.

Ice in the LO2 feedline support brackets and bellows had melted. No loose foam or TPS damage was visible.

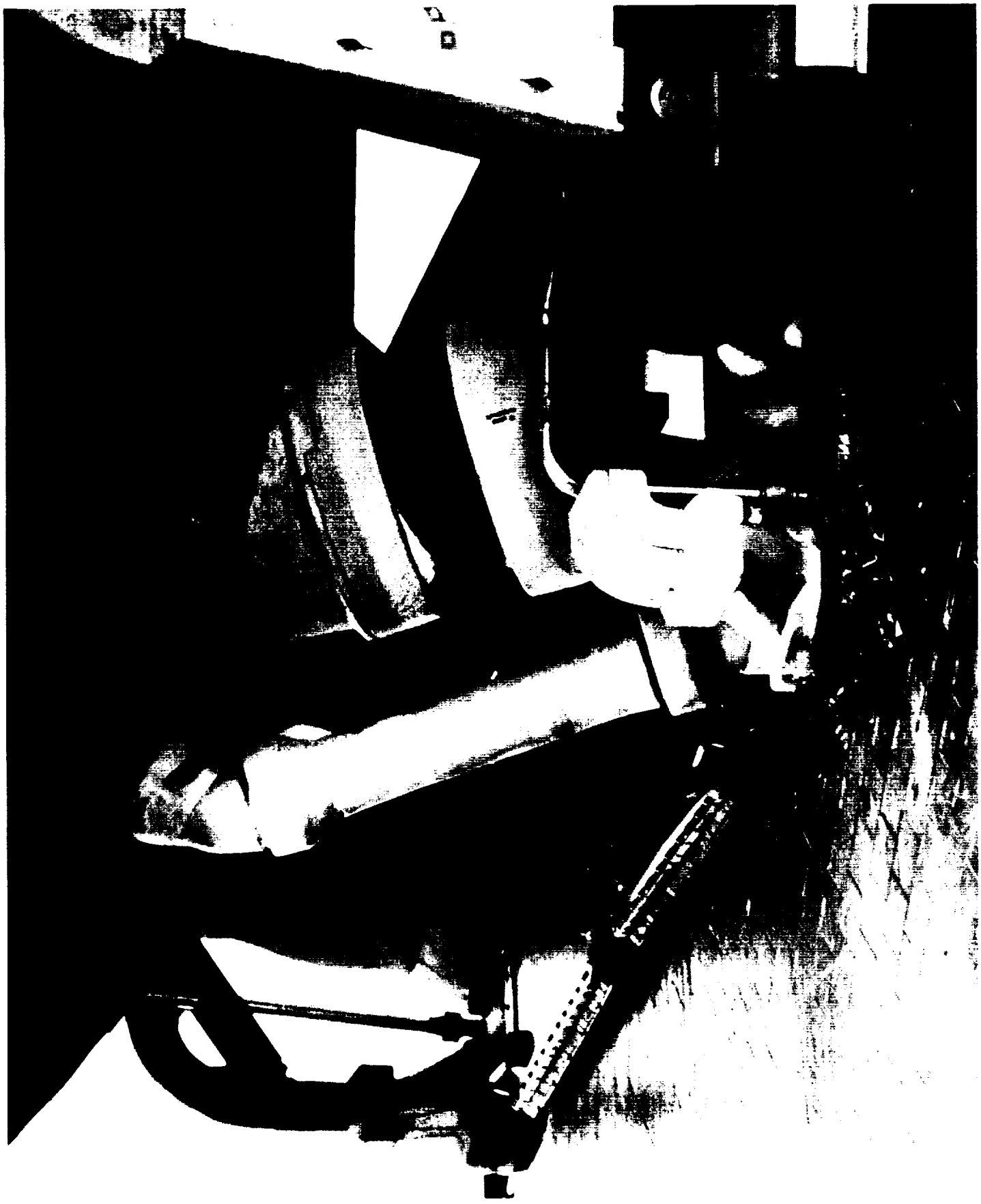
Bipod jack pad closeouts were intact and flush with adjacent LH2 tank-to-intertank flange closeout foam.

The 8 x 3/8-inch crack in the -Y ET/SRB vertical strut cable tray forward surface TPS (reported during the Ice Inspection) was still visible. A 5 x 1/8-inch crack was present in the +Y ET/SRB vertical strut cable tray aft surface TPS. The crack had an 1/8-inch offset, approximately, due to structural deflection. Further inspection revealed the crack continued into the vertical strut/LH2 tank crotch area and progressed 6 inches upward within the BX-250 closeout. No ice was visible in the crack.

Ice on the ET/SRB fittings, the LO2 and LH2 ET/ORB umbilical purge vents, the LH2 recirculation line bellows and burst disks, the LH2 feedline bellows, and the LH2 umbilical 17-inch flapper valve torque tool access port closeout plug had not yet completely melted. More ice than usual remained on the LH2 ET/ORB umbilical aft pyrotechnic canister closeout bondlines.

Ice/frost spots that had formed on the aft dome -Z manhole cover closeouts during detanking had melted and no TPS damage was visible.

No significant vehicle damage was observed during the external post drain inspection. Two PR's were generated as a result of this inspection: 1) missing topcoat in the footprint area; 2) 5-inch crack in the +Y vertical strut cable tray TPS.



Post drain inspection revealed ice on the pyro canister purge vents, plate gap purge vents, LH2 recirculation line bellows, and LH2 feedline bellows - an expected condition. There were no TPS anomalies.

4.0 LAUNCH

STS-57 was launched at 13:07:21.989 GMT (9:07 a.m. local) on 21 June 1993.

4.1 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 21 June 1993 from 0510 to 0615 hours during the two hour built-in-hold at T-3 hours in the countdown. There were no Launch Commit Criteria, OMRS, or NSTS-08303 criteria violations. There were no conditions outside of the established data base. Ambient weather conditions at the time of the inspection were:

Temperature:	76.3 Degrees F
Relative Humidity:	76.7 Percent
Wind Speed:	4.2 Knots
Wind Direction:	147 Degrees

Cryogenic loading of the External Tank began almost two hours late due to the replacement of a malfunctioning nitrogen regulator in the MLP. An inspection of the vehicle by the Ice Team was necessary since the ET had already experienced one cryoloading. However, the regulator problem and a short launch window dictated the need for an abbreviated inspection of the vehicle. Expedited visual assessment with minimal photography/ infrared temperature measurements was performed.

4.2 ORBITER

No Orbiter tile or RCC panel anomalies were observed. All RCS thruster paper covers, including the two wet covers on the R4U and L2U nozzles, and water spray boiler plugs were intact. Typical ice/frost accumulations were present at the SSME #1 heat shield-to-nozzle interface and drain line. Condensate was present on the SSME engine mounted heat shields, but the base heat shield tiles were dry. An infrared scan revealed no unusual temperature gradients on the base heat shield or engine mounted heat shields. No unusual vapors originated from inside the SSME nozzles.

4.3 SOLID ROCKET BOOSTERS

No SRB anomalies or loose ablator/cork were observed. The K5NA closeouts of the aft booster stiffener ring splice plates were intact. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 79 degrees F, which was within the required range of 44-86 degrees F.

STS- 57	TEST S0007 LAUNCH															DATE: 21 June 1993					T-0 TIME: 09:07:21.989 DATE: 6/21/93				NASA KSC Ice/Frost/Debris Team
ORBITER 105	ET 58	SRB BI-059	MLP 2	PAD B	LO2 CHILLDOWN TIME: 02:19 SLOW FILL TIME: 02:46					FAST FILL TIME: 02:58 REPLENISH TIME: 05:02					LH2 CHILLDOWN TIME: 02:08 SLOW FILL TIME: 02:16				FAST FILL TIME: 03:01 REPLENISH TIME: 04:47						
TIME (EDT)	CONDITIONS					LO2 TANK STA 370 TO 540					LO2 TANK STA 550 TO 852					LH2 TANK STA 1130 TO 1380					LH2 TANK STA 1380 TO 2058				
	TEMP F	REL HUM. %	DEW PT F	WIND VEL KNTS	WIND DIR DEG	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR	REG	LOCAL VEL KNTS	SOFI TEMP	COND RATE IN/HR	ICE RATE IN/HR
0215	77.40	73.8	68.76	7	122	II	4.13	65.04	0.0018	-0.1757	II	4.13	60.40	0.0036	-0.1452	II	2.24	53.43	0.0036	-0.0737	II	9.73	65.27	0.0035	-0.3253
0230	77.20	74.2	68.72	7	136	II	4.13	64.93	0.0018	-0.1749	II	4.13	60.28	0.0037	-0.1444	II	2.24	53.28	0.0036	-0.0731	II	9.73	65.16	0.0036	-0.3240
0245	77.40	74.6	69.07	8	134	II	4.72	65.81	0.0018	-0.1978	II	4.72	61.64	0.0037	-0.1667	II	2.56	55.09	0.0037	-0.0859	II	11.12	66.11	0.0034	-0.3736
0300	77.40	74.0	68.84	4	130	II	2.36	62.29	0.0019	-0.1128	II	2.36	55.43	0.0034	-0.0837	II	1.28	51.03	0.0033	-0.0739	II	5.56	61.92	0.0040	-0.1884
0315	77.40	74.4	68.99	7	126	II	4.13	65.19	0.0019	-0.1768	II	4.13	60.56	0.0037	-0.1462	II	2.24	53.58	0.0036	-0.0743	II	9.73	65.43	0.0036	-0.3274
0330	77.20	74.2	68.72	7	133	II	4.13	64.93	0.0018	-0.1749	II	4.13	60.28	0.0037	-0.1444	II	2.24	53.28	0.0036	-0.0731	II	9.73	65.16	0.0036	-0.3240
0345	77.20	74.6	68.87	6	137	II	3.54	64.32	0.0019	-0.1549	II	3.54	59.11	0.0037	-0.1248	II	1.92	51.63	0.0034	-0.0734	II	8.34	64.46	0.0038	-0.2800
0400	77.40	74.8	69.14	5	145	II	2.95	63.68	0.0020	-0.1353	II	2.95	57.77	0.0036	-0.1056	II	1.60	51.20	0.0034	-0.0747	II	6.95	63.64	0.0040	-0.2368
0415	76.20	75.2	68.11	6	126	II	3.54	63.38	0.0019	-0.1492	II	3.54	58.11	0.0036	-0.1193	II	1.92	50.53	0.0034	-0.0685	II	8.34	63.55	0.0039	-0.2699
0430	76.60	75.4	68.58	7	123	II	4.13	64.58	0.0019	-0.1726	II	4.13	59.91	0.0037	-0.1421	II	2.24	52.85	0.0036	-0.0714	II	9.73	64.85	0.0037	-0.3200
0445	76.80	76.0	69.00	6	130	II	3.54	64.23	0.0020	-0.1544	II	3.54	59.01	0.0037	-0.1243	II	1.92	51.48	0.0035	-0.0726	II	8.34	64.40	0.0040	-0.2794
0500	77.00	75.2	68.90	6	137	II	3.54	64.25	0.0020	-0.1545	II	3.54	59.04	0.0037	-0.1244	II	1.92	51.53	0.0034	-0.0729	II	8.34	64.40	0.0039	-0.2794
0515	77.00	75.4	68.98	4	157	II	2.36	62.17	0.0020	-0.1125	II	2.36	55.30	0.0034	-0.0832	II	1.28	50.84	0.0034	-0.0731	II	5.56	61.84	0.0042	-0.1878
0530	76.80	76.4	69.15	3	146	II	1.77	60.47	0.0019	-0.1032	II	1.77	52.28	0.0032	-0.0786	II	0.96	50.60	0.0034	-0.0730	II	4.17	59.57	0.0042	-0.1410
0545	76.00	77.6	68.80	5	146	II	2.95	62.80	0.0021	-0.1507	II	2.95	58.82	0.0037	-0.1011	II	1.60	50.07	0.0034	-0.0697	II	6.95	63.84	0.0043	-0.2293
0600	76.00	77.0	68.68	4	147	II	2.36	61.42	0.0020	-0.1089	II	2.36	54.49	0.0035	-0.0789	II	1.28	49.94	0.0034	-0.0691	II	5.56	61.14	0.0043	-0.1864
0615	75.60	77.2	68.26	5	146	II	2.95	62.26	0.0021	-0.1279	II	2.95	56.25	0.0036	-0.0954	II	1.60	49.60	0.0034	-0.0671	II	6.95	62.39	0.0042	-0.2242
0630	75.60	77.8	68.48	5	141	II	2.95	62.41	0.0021	-0.1286	II	2.95	56.40	0.0037	-0.0991	II	1.60	49.62	0.0034	-0.0677	II	6.95	62.46	0.0043	-0.2257
0645	77.20	77.8	70.06	3	135	II	1.77	61.26	0.0020	-0.1089	II	1.77	53.12	0.0033	-0.0823	II	0.96	51.57	0.0035	-0.0788	II	4.17	60.39	0.0044	-0.1462
0700	77.00	78.2	70.00	2	147	II	1.18	59.76	0.0019	-0.1062	II	1.18	52.82	0.0033	-0.0815	II	0.64	51.41	0.0035	-0.0759	II	2.78	58.39	0.0041	-0.0958
0715	77.40	79.4	70.83	3	135	II	1.77	61.86	0.0021	-0.1097	II	1.77	53.76	0.0034	-0.0850	II	0.96	52.14	0.0036	-0.0793	II	4.17	61.03	0.0045	-0.1504
0730	77.00	77.8	69.86	1	181	II	0.59	59.68	0.0019	-0.1058	II	0.59	52.74	0.0033	-0.0811	II	0.42	51.33	0.0035	-0.0755	II	0.38	51.33	0.0035	-0.0755
0745	77.80	74.6	69.46	1	203	II	0.59	59.96	0.0018	-0.1069	II	0.59	53.04	0.0031	-0.0823	II	0.32	51.64	0.0034	-0.0767	II	1.36	51.64	0.0034	-0.0767
0800	80.00	71.6	70.47	3	130	II	1.77	62.99	0.0018	-0.1162	II	1.77	55.03	0.0031	-0.0916	II	0.96	53.66	0.0034	-0.0860	II	4.17	61.95	0.0039	-0.1560
0815	80.00	71.6	70.47	3	130	II	1.77	62.99	0.0018	-0.1162	II	1.77	55.03	0.0031	-0.0916	II	0.96	53.66	0.0034	-0.0860	II	4.17	61.95	0.0039	-0.1560
0830	81.00	66.8	69.49	4	141	II	2.36	64.46	0.0015	-0.1228	II	2.36	57.79	0.0031	-0.0936	II	1.28	53.76	0.0031	-0.0862	II	5.56	63.87	0.0034	-0.2038
0845	81.20	65.0	68.91	4	85	II	2.36	64.19	0.0014	-0.1215	II	2.36	57.52	0.0029	-0.0924	II	2.20	55.49	0.0032	-0.0852	II	4.88	62.63	0.0033	-0.1774
0900	80.80	64.0	68.08	7	78	II	4.13	66.03	0.0010	-0.1822	II	4.13	61.48	0.0029	-0.1516	II	3.85	60.05	0.0032	-0.1365	II	8.54	65.40	0.0024	-0.2951
T-0	81.40	64.0	68.67	5	92	II	2.95	65.22	0.0013	-0.1434	II	2.95	59.48	0.0029	-0.1137	II	2.75	57.69	0.0032	-0.1009	II	6.10	64.09	0.0030	-0.2191
AVG.	77.69	74.09	69.11	4.76	SSE		2.81	63.19				2.81	57.07				1.65	52.49				6.48	62.25		

Period of Ice Team Inspection

Figure 4. "SURFICE" Computer Predictions

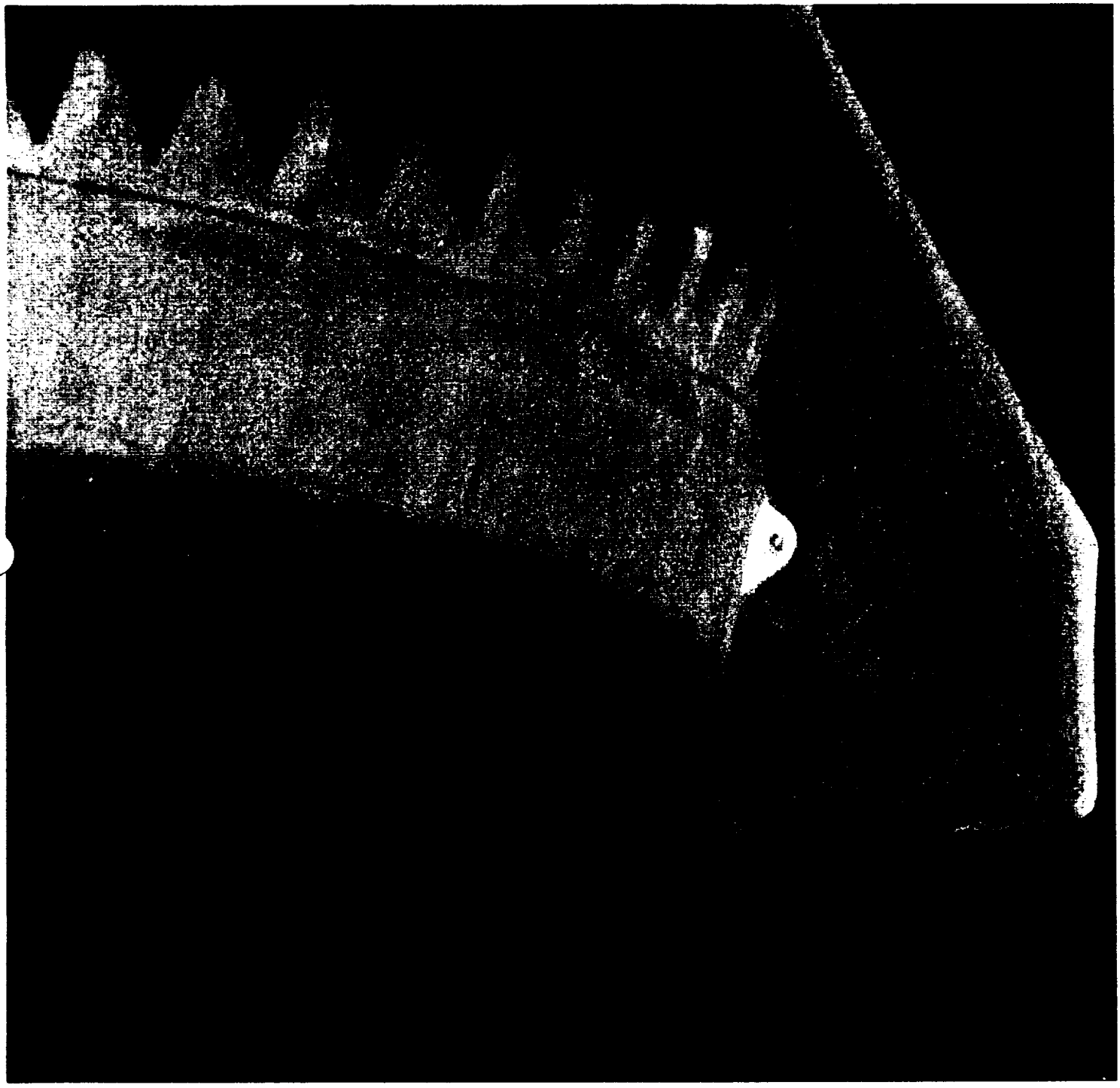
4.5 FACILITY

All SRB sound suppression water troughs were filled and properly configured for launch. There was no debris on the MLP deck or in the SRB holddown post areas.

No leaks were observed on either the LO2 or LH2 Orbiter T-0 umbilicals. Typical accumulations of ice/frost were present on the cryogenic lines and purge shrouds.

There was no apparent hydrogen leakage anywhere on the GH2 vent line or GUCP. Some ice and frost, which was expected, had accumulated on the GUCP legs and on the uninsulated parts of the umbilical carrier plate.

The GOX seals were in nominal configuration. No ET nosecone/ footprint damage was visible after the GOX vent hood was retracted. No icicles were present on the GOX vent ducts at the time of launch.



A 2-inch diameter ice/frost accumulation, which first appeared during drain, had formed on the -Y bipod spindle housing-to-ET interface bondline.

5.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspection of the MLP and FSS/RSS was conducted on 21 June 1993 from Launch + 2 to 3-1/2 hours.

A frangible nut web, 2-1/4" x 5/16", was found on the stud in holddown post (HDP) #2. A Q-felt plug from the Orbiter base heat shield was found on the southwest pad apron.

Three metal facility items (1-3/8" x 1/4" bolt, 5/8" x 1/4" bolt, 7/8" diameter washer) lay on the MLP deck near HDP #8 between the sound suppression water pipe and SRB exhaust hole.

South SRB HDP erosion was typical. All south HDP EPON shoe shim material was intact. There was no visual indication of a stud hang-up on any of the south holddown posts. All of the north HDP doghouse blast covers were in the closed position. Plume erosion of the covers was typical with the exception of the HDP #4 cover, which had several burn-through holes. The SRB aft skirt purge lines were in place, but slightly damaged. The SRB T-0 umbilicals exhibited minor damage.

The Tail Service Masts (TSM), Orbiter Access Arm (OAA), and GOX vent arm sustained only minor damage. The GH2 vent line was latched on the eighth tooth of the latching mechanism and had no loose cables (static retract lanyard). The GH2 vent line appeared to have retracted nominally and showed typical signs of SRB plume impingement. The ET intertank access structure also sustained typical plume heating effects.

Typical damage to the facility included:

1. An aluminum ring, 3 inches in diameter, lay on the pad apron under the RSS. A 2-1/4" x 1/4" diameter flexible white tube with stainless steel clamp and UV detector cap were found in the SSME flame trench.

2. A piece of porcelain, two cable tray clamps, a 16" long by 1/2" strip of aluminum, a FOD sign, a loose bolt, and a grating clamp were found on various levels of the FSS/RSS.

All seven emergency egress slidewire baskets were secured on the FSS 195 foot level and sustained no launch damage.

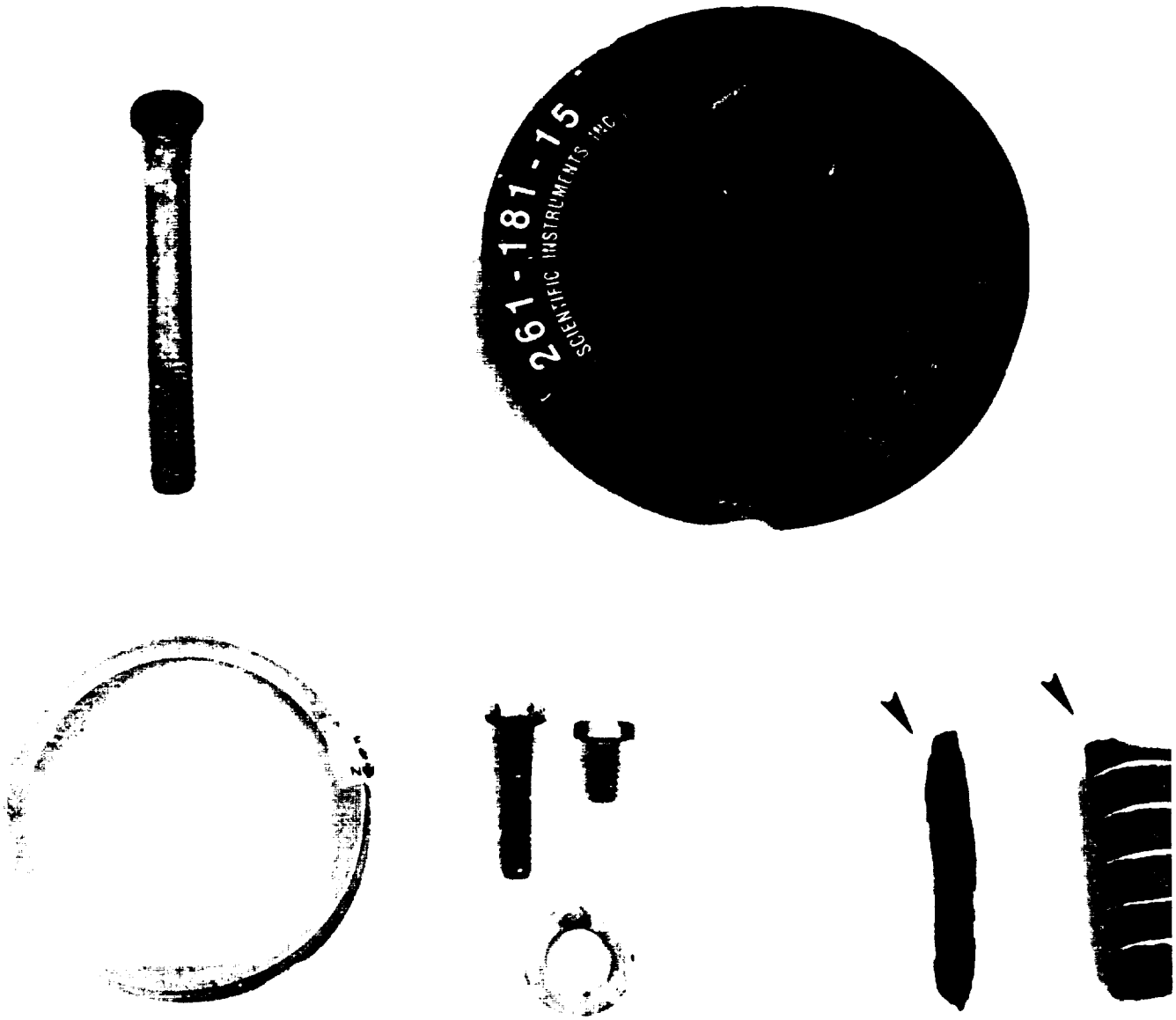
All composite material samples on the FSS side 1, levels 135, 175, 215, and 255 hand rails, were intact and undamaged.

A walkdown of the pad acreage and beach was completed on 22 June 1993. No flight hardware or TPS material was found.

Post launch pad inspection anomalies are listed in Section 10.

SRB plume erosion of the north HDP blast covers was typical with the exception of the HDP #4 cover, which had several burn-through holes.

All composite material samples attached to the
FSS east side handrails were intact and undamaged



A frangible nut web, 2-1/4" by 5/16", was found on the stud in holddown post #2. A Q-felt plug from the Orbiter base heat shield was found on the southwest pad apron.

6.0 FILM REVIEW AND PROBLEM REPORTS

Anomalies observed in the Film Review were presented to the Mission Management Team, Shuttle managers, and vehicle systems engineers. Two IFA candidates were proposed as a result of the film review.

6.1 LAUNCH FILM AND VIDEO SUMMARY

A total of 104 films and videos, which included forty-one 16mm films, twenty 35mm films, four 70mm films, and thirty-nine videos, were reviewed starting on launch day.

No major vehicle damage or lost flight hardware was observed that would have affected the mission.

Free burning hydrogen drifted under the body flap prior to SSME ignition. Frost covered the SSME nozzles. SSME ignition, Mach diamond formation, and gimbal profile appeared normal (C/S-2 STI, OTV 151, 163, 170, 171, E-6, 19, 20). Flashes occurred in the SSME plumes prior to and after T-0 (E-2, 3).

Fore-and-aft movement of the Orbiter base heat shield in the centerline area between the SSME cluster occurred during engine start-up. The motion was similar to that observed on previous launches (E-76, 77).

SSME ignition caused numerous pieces of ice to fall from the ET/Orbiter umbilicals. There were no unusual vapors or cryogenic drips from the ET/ORB umbilicals during tanking, stable replenish, ignition, liftoff, or tower clear (OTV 109, 150, 154, 163, 164).

Several pieces of ice from the GUCP area fell aft along the -Z side of the tank after SSME ignition (E-4).

The Orbiter LH2 and LO2 T-0 umbilicals disconnected and retracted properly (OTV 149, 150, 163). GUCP disconnect and retraction from the External Tank was normal (E-33, 34). The GH2 vent arm retracted and latched with no rebound (OTV 160). Some slack in the static retract lanyard caused the cable to contact the GUCP leg during latchback (E-41, 42, 48, 50). Excessive slack on the cable attached to the GUCP J2 electrical connector caused the cable to momentarily catch on a intertank access platform hand rail during retraction (E-42, 48).

No stud hang-ups occurred on any of the holddown posts. Two frangible nut pieces fell from the HDP #2 DCS/stud hole after liftoff (E-8). A loose SRB sound suppression water trough cloth parts tag was visible near HDP #2 (E-8). The north holddown post blast covers closed normally.

Two frangible nut pieces fell from the HDP #2 DCS/stud hole after liftoff.

Excessive slack on the cable attached to the GUCP J2 electrical connector caused the cable to momentarily catch on an intertank access platform hand rail during retraction.

6.2 ON-ORBIT FILM AND VIDEO SUMMARY

Thirty-seven handheld still images (DTO-0312) and video were obtained of the ET after separation from the Orbiter by the flight crew. OV-105 was equipped to carry two umbilical cameras. The 16mm camera with the 10mm lens was not flown in the ET/ORB LH2 umbilical due to a structural interference problem.

No major vehicle damage or lost flight hardware was observed that would have been a safety of flight concern.

SRB separation from the ET was nominal. No anomalies were observed on the LH SRB segment cases and joints, forward skirt, and frustum. The left forward BSM aero heat shield covers were fully opened and latched.

ET separation from the Orbiter appeared nominal. Pieces of ice, frozen hydrogen, and foam drifted by the ET/ORB LH2 umbilical camera. The BSM burn scars on the LO2 tank were typical. No anomalies were observed on the nosecone, LO2 tank acreage, LH2 tank acreage, PAL ramps, RSS antennae, flight door, bipod ramps, aft hard point, and aft dome acreage. Exhaust plume recirculation and aft dome heating caused the usual charring and "popcorning" of the NCFI foam.

The lightning contact strip was missing from the top of the LO2 ET/ORB umbilical (the others were intact). TPS damage had occurred on the top inboard section of the umbilical. Foam was missing from the top, bottom, and outboard sides of the cable tray (horizontal section). Eight TPS divots were visible in the cable tray vertical section.

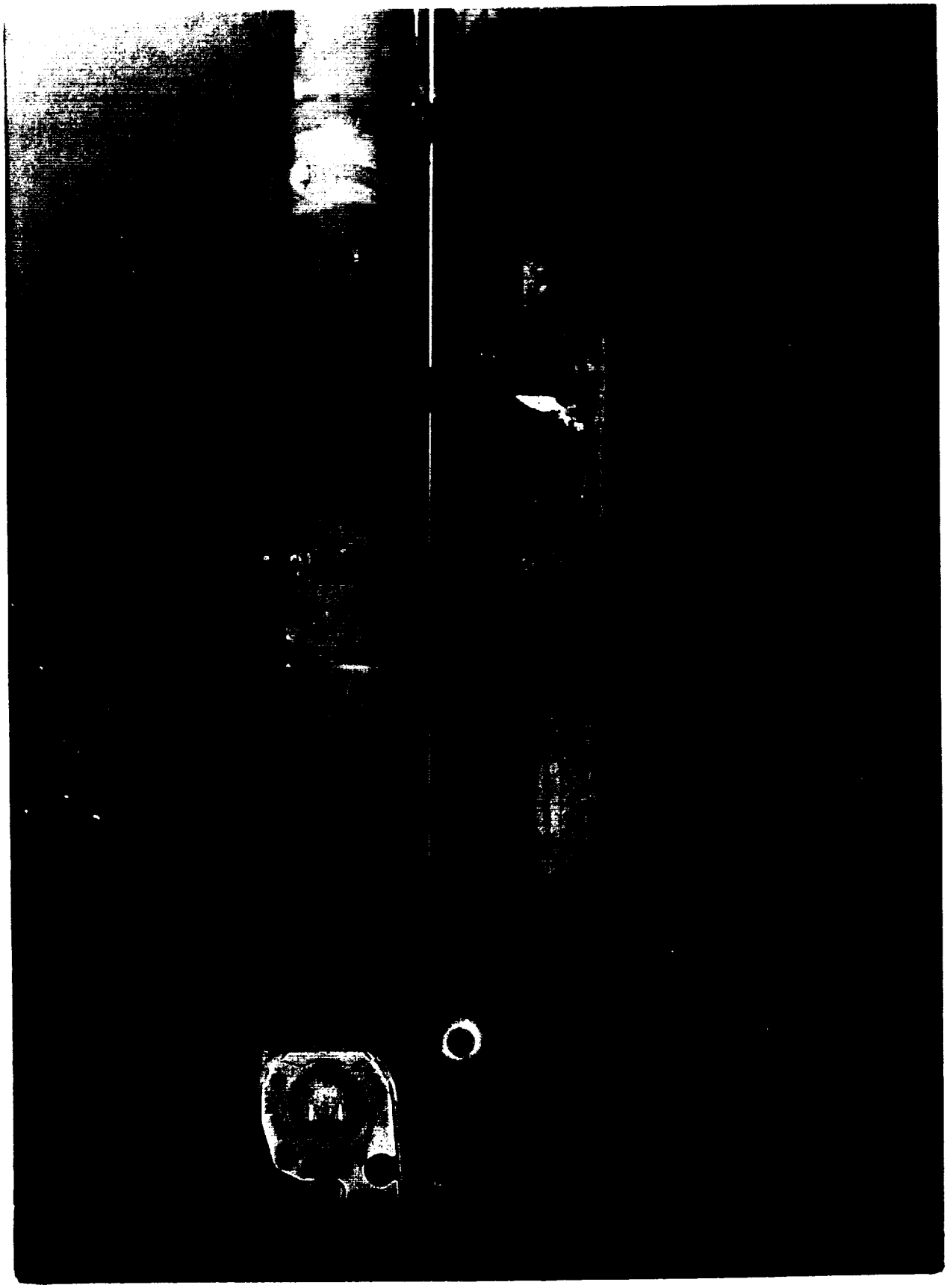
The red purge seal was missing from the LH2 ET/ORB umbilical near the 4-inch disconnect (still attached to the Orbiter after landing) and at the top outboard section. A piece of white RTV drifting by the camera lens may also have originated from the top outboard section. TPS damage had occurred on the inboard side of the umbilical and a large piece of foam, which measured approximately 2 feet long by 4 inches wide by as much as 1 inch thick, had partially separated from the umbilical. TPS on the top surface of the umbilical had peeled back in two places.

The red seals at both EO fittings (EO-2 and EO-3) were loose and dangling by the retaining cords.

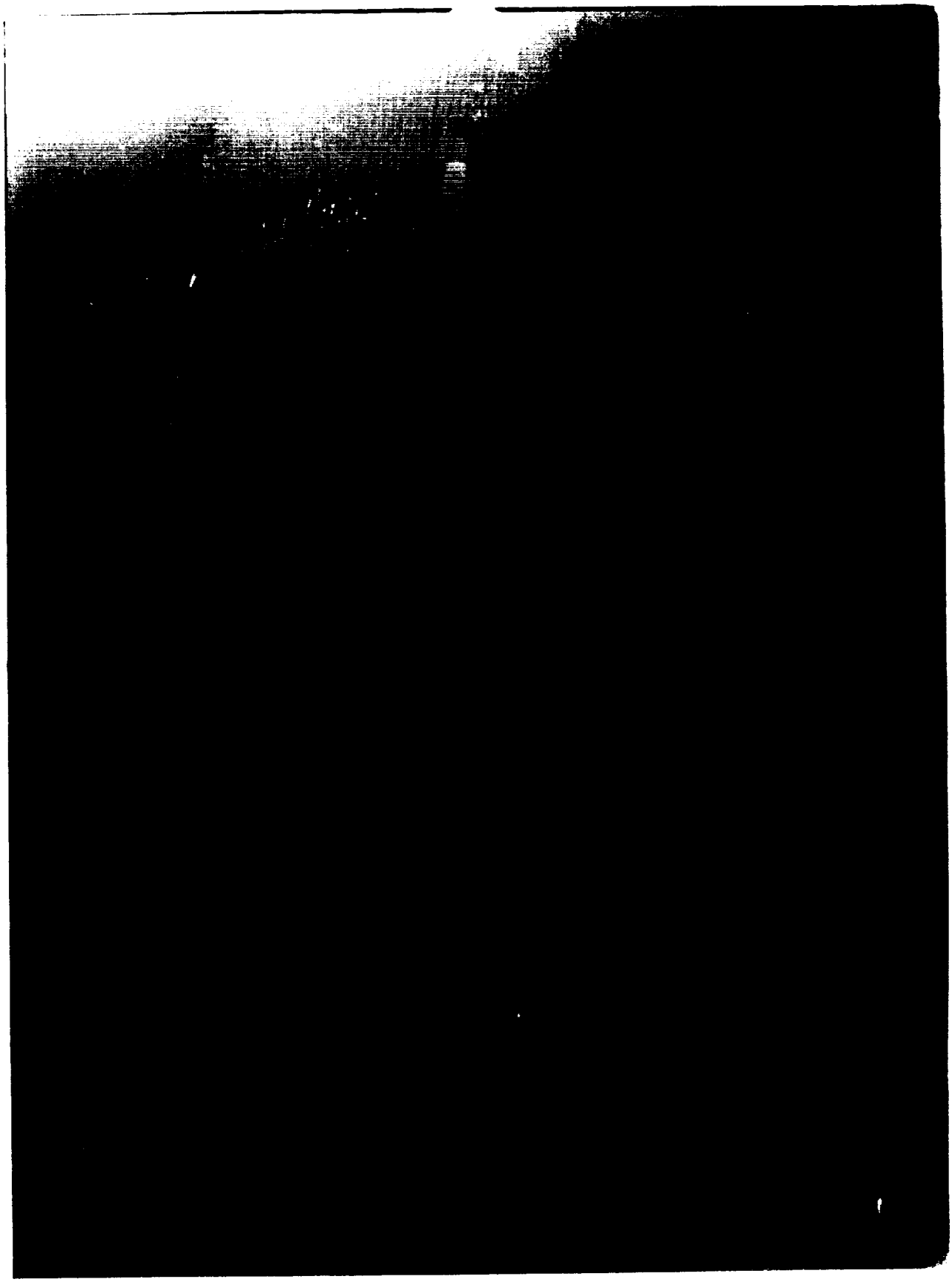
A divot, 6-8 inches in diameter, was present in the -Y (LH) longeron closeout.

Foam was missing from the +Y thrust strut flange and primer/ metal substrate was exposed.

The red purge seal was missing from the ET/ORB LH2 umbilical near the 4-inch disconnect and at the top outboard section. TPS was damaged on the inboard side of the umbilical and a large piece of foam, which measured approximately 2 feet long by 4 inches wide by as much as 1 inch thick, had partially separated from the umbilical. TPS on top of the umbilical had peeled back in two places.



The lightning contact strip was missing from the top of the LO2 ET/ORB umbilical (the others were intact). TPS was damaged on the top inboard side of the umbilical. The red seal at the EO fitting was loose and dangling by the retaining cord. Foam was missing from the +Y thrust strut flange and primer/metal substrate was exposed.



At least 70 small divots, 3-4 inches in diameter, occurred on the intertank stringers forward of the bipods. Seven small divots were visible in the LH2 tank-to-intertank flange closeout between the bipods.

Nine divots occurred in a rough line along the edge of the -Y thrust panel. A divot is visible in the LH2 tank-to-intertank flange closeout and the -Y longeron closeout. There were no TPS anomalies on the LH2 and LO2 tank acreage.

6.3 LANDING FILM AND VIDEO SUMMARY

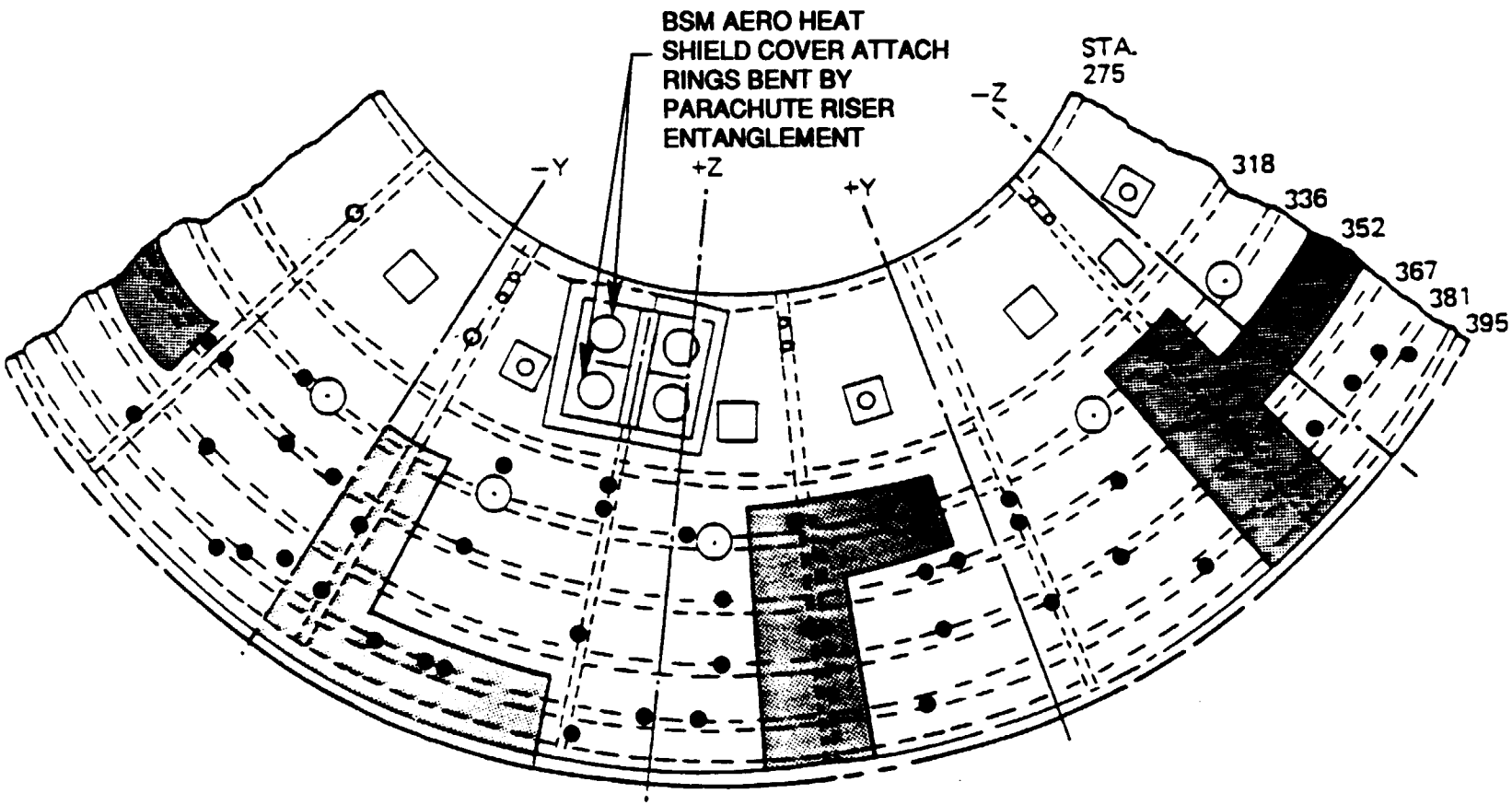
A total of nine 35mm large format films, seven 16mm high speed films, and 10 videos were reviewed.

Orbiter performance in the Heading Alignment Circle (HAC) and final approach appeared normal. There were no anomalies when the landing gear was extended. Touchdown of the main gear was nominal.

The drag chute was deployed just after breakover, but before the nose gear contacted the runway. Drag chute deployment appeared nominal though the parachute risers contacted a tile on the vertical stabilizer "stinger". The drag chute door appeared to get caught in the RH wing tip vortex and landed near the east edge of the runway. A crosswind blew the drag chute to the right of the Orbiter centerline.

Touchdown of the nose landing gear was smooth. There were no anomalies during rollout.

FIGURE 5. **RIGHT SRB FRUSTUM**



MISSING TPS

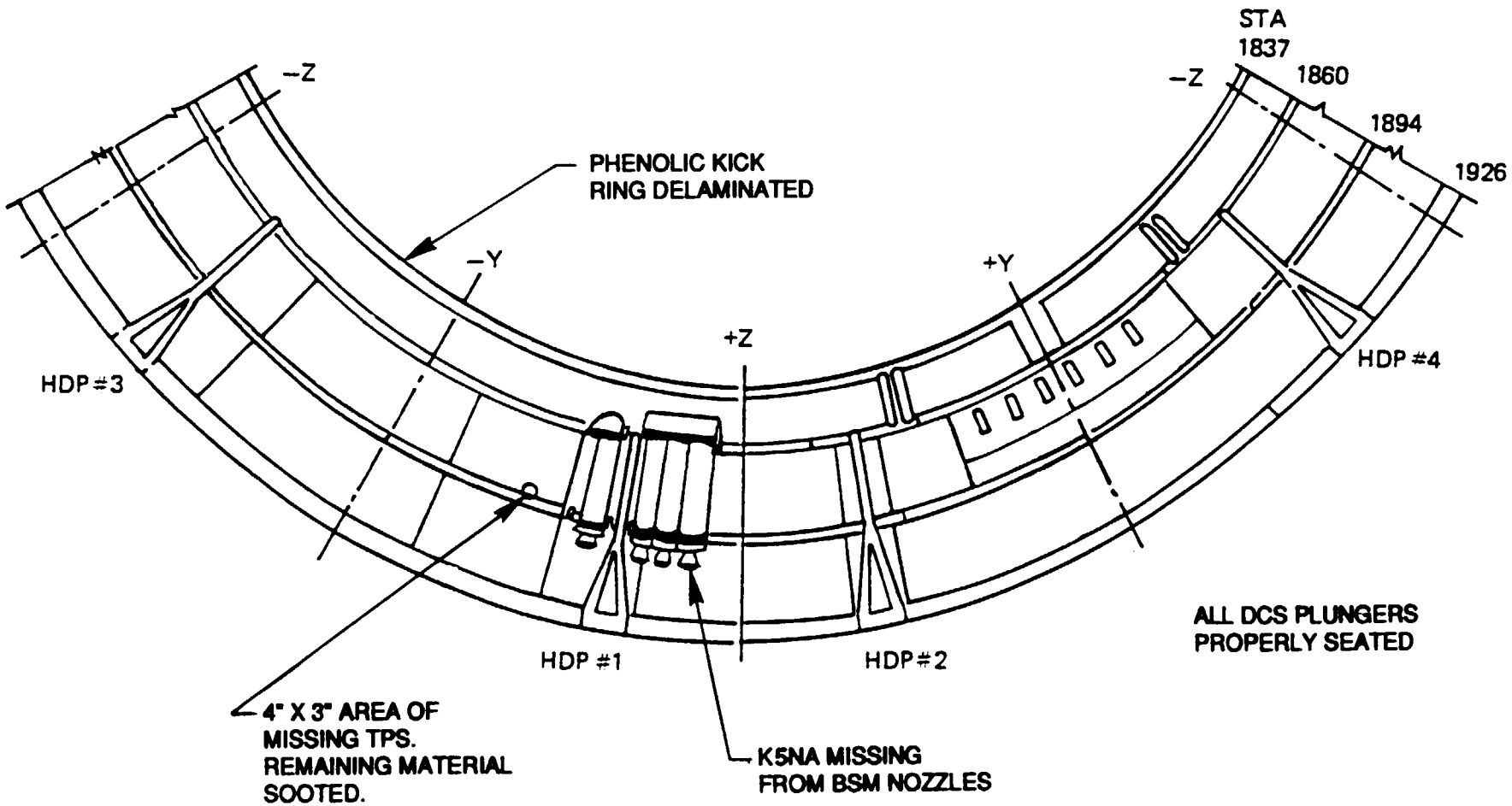
2 O

DEBONDS

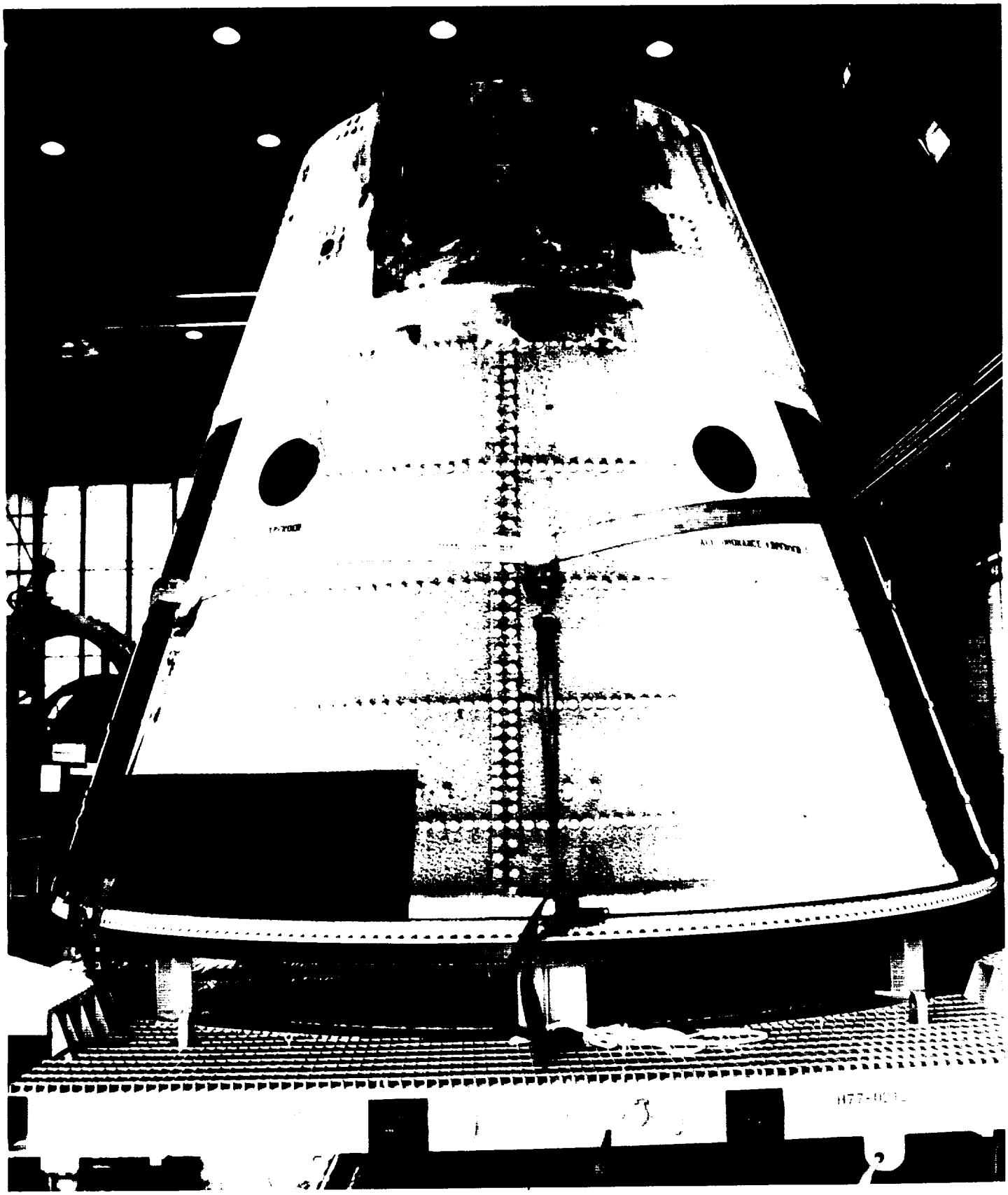
46 ●

EGG/V-326

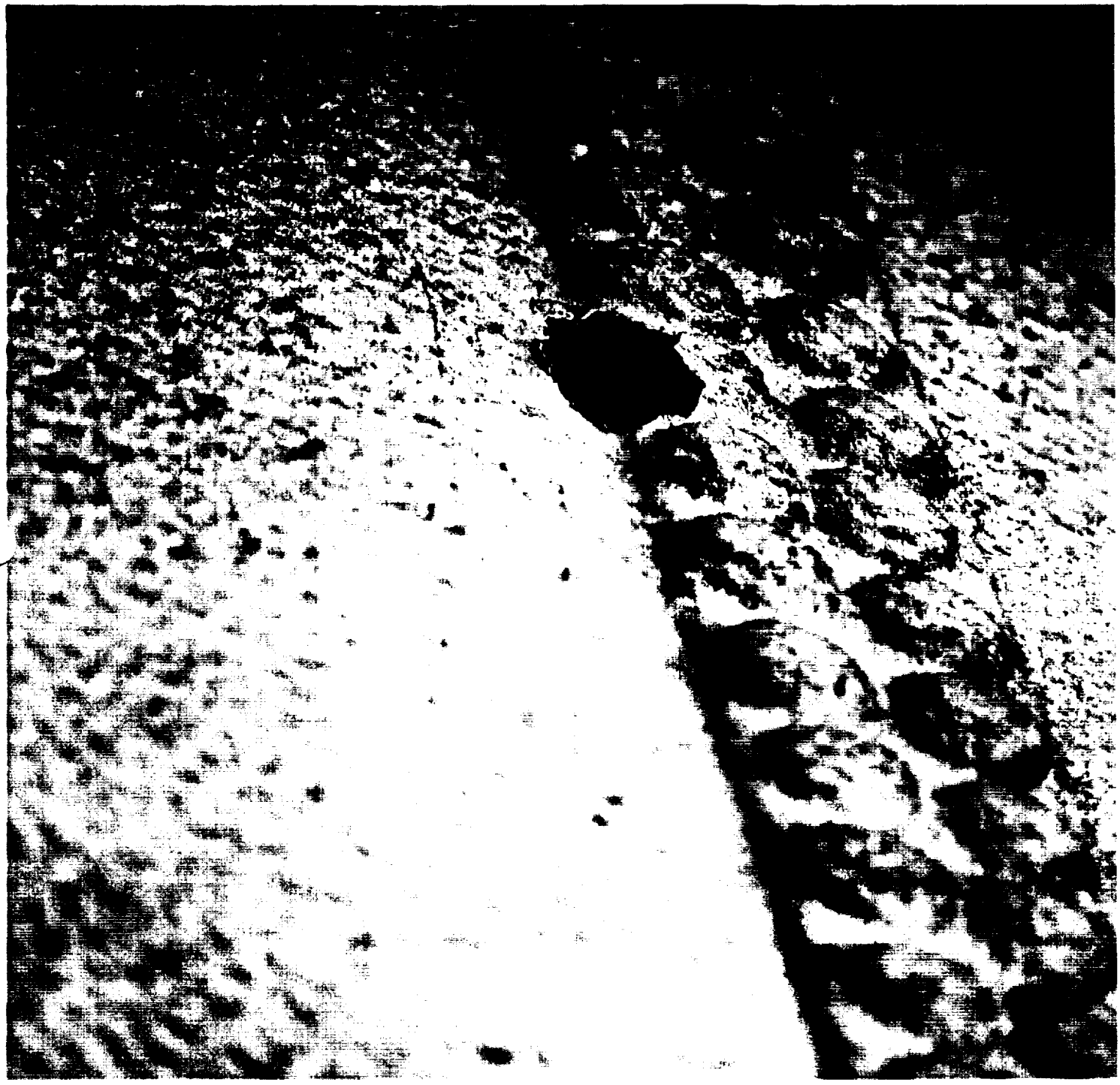
FIGURE 7. **RIGHT SRB AFT SKIRT EXTERIOR TPS**



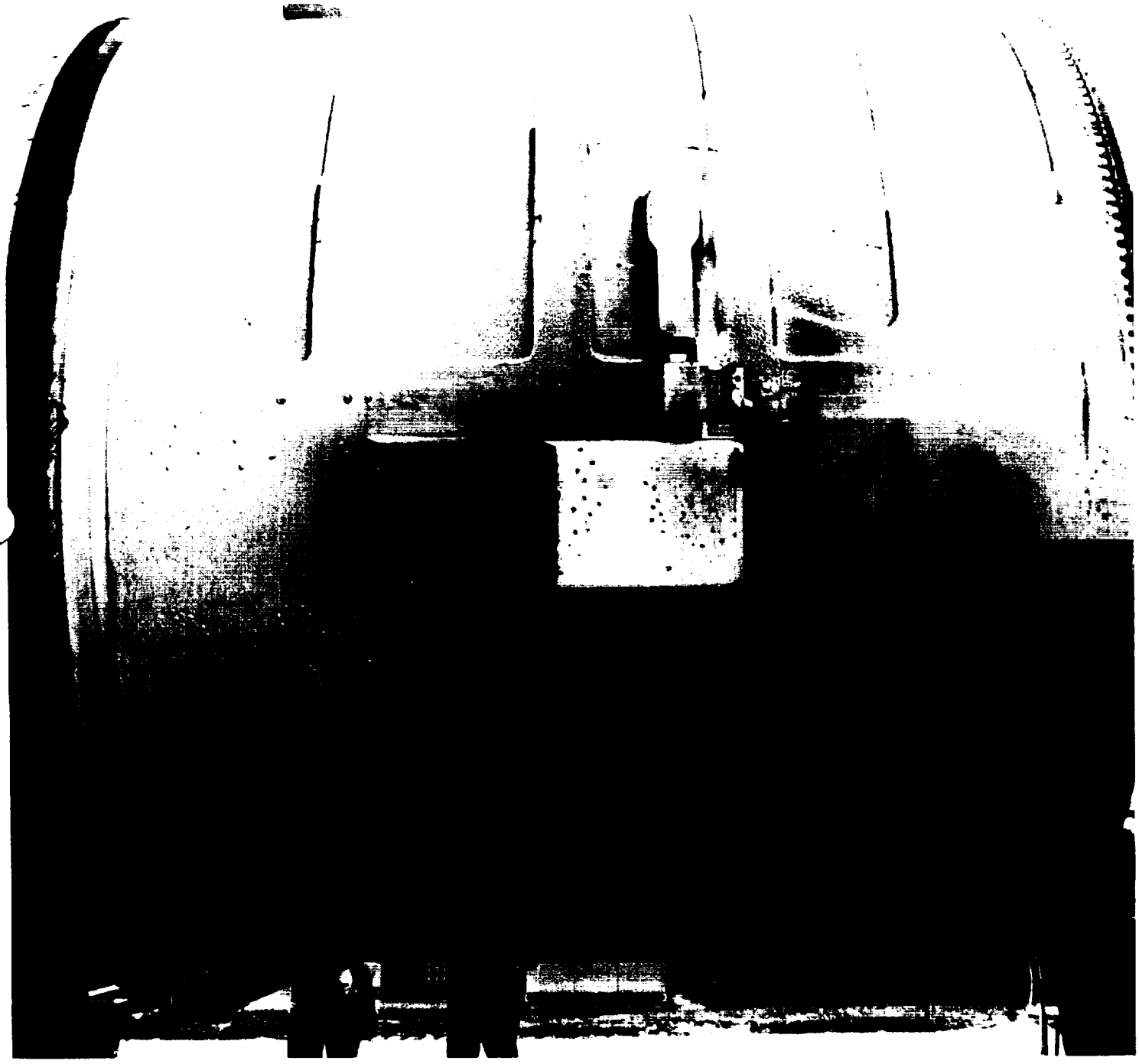
EGG/V 326C



The RH frustum had 46 MSA-2 debonds over fasteners and two areas of missing MSA-2. All BSM aero heatshield covers were locked in the fully opened position, though the two left cover attach rings had been bent by parachute riser entanglement.



Loss of MSA-2 TPS from a frustum fastener



The RH forward skirt acreage MSA-2 was missing no TPS, but had one MSA-2 debond near the forward attach fitting. Both RSS antenna covers/phenolic base plates were intact.

7.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The LH frustum was missing no TPS, but had 27 MSA-2 debonds over fasteners. Minor localized blistering of the Hypalon paint had occurred along the 395 ring (Figure 8). The BSM aero heat shield covers were locked in the fully opened position.

The LH forward skirt acreage exhibited no debonds or missing TPS. Both RSS antennae covers/phenolic base plates were intact. Minor blistering of the Hypalon paint occurred near the ET/SRB attach point and on the systems tunnel cover. No pins were missing from the frustum severance ring. The forward separation bolt appeared to have separated cleanly.

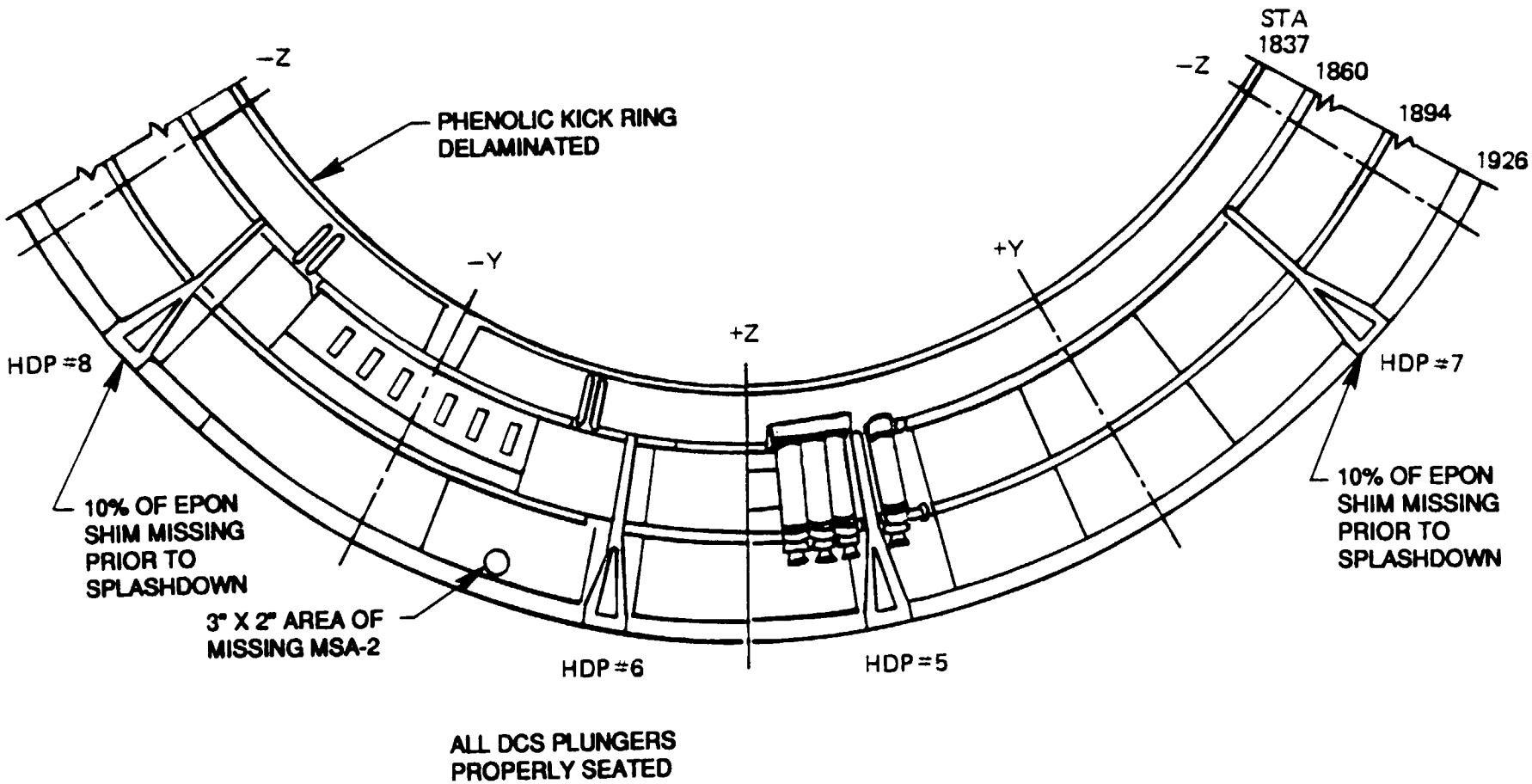
The Field Joint Protection System (FJPS) closeouts were in good condition. In general, minor trailing edge damage to the FJPS and the GEI cork runs were attributed to debris resulting from severance of the nozzle extension. Paint was missing from eight areas on the aft center segment.

Separation of the aft ET/SRB struts appeared normal. The ET/SRB aft struts, ETA ring, IEA, and IEA covers appeared undamaged. The K5NA closeout material on the upper strut fairing was intact. All three aft booster stiffener rings were damaged by water impact. The stiffener ring splice plate closeouts were intact and no K5NA material was missing.

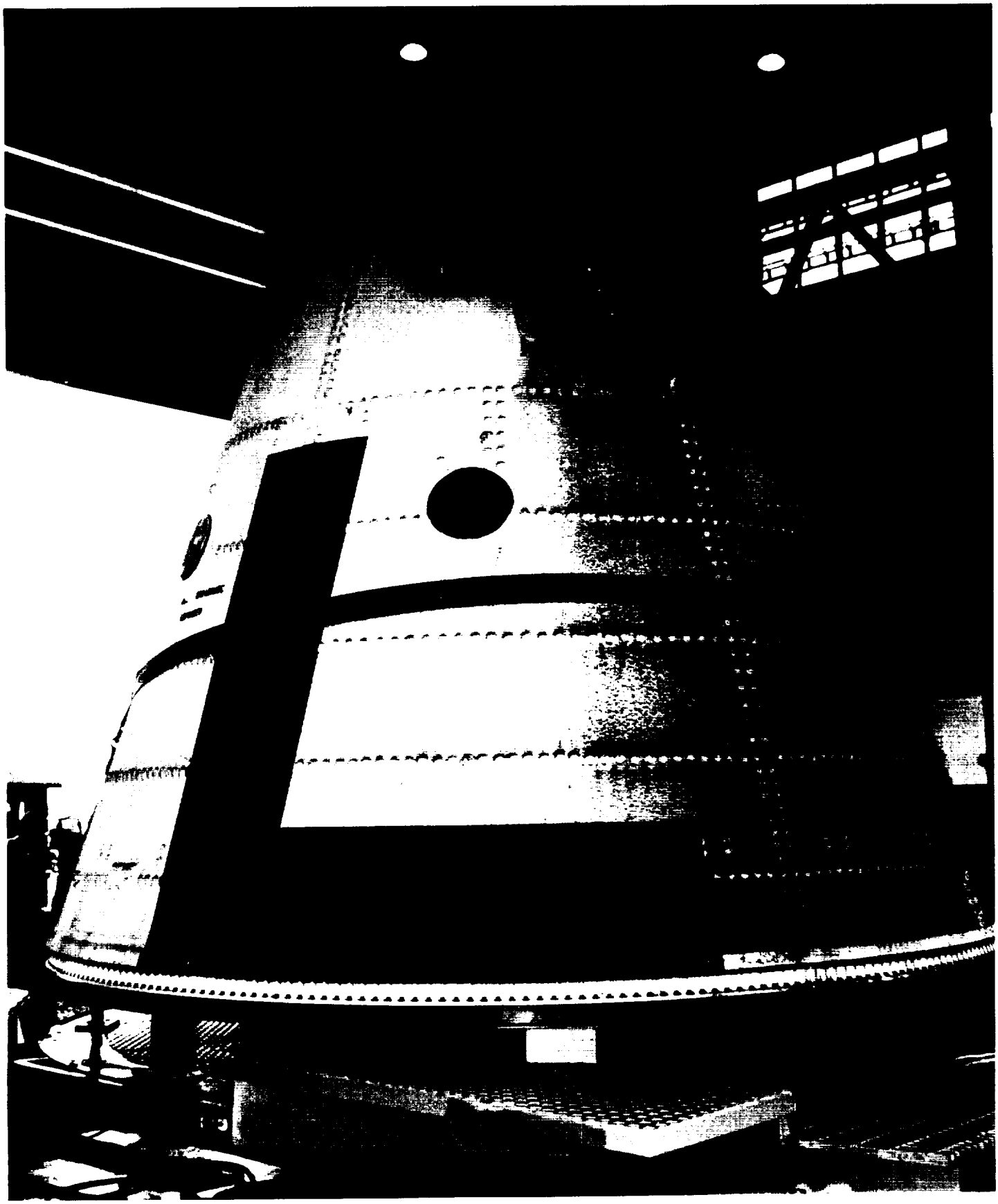
The phenolic material on the kick ring was delaminated. The K5NA closeouts (protective domes) on the kick ring forward and aft fasteners are no longer used. RTV-133 has replaced the K5NA over the forward fasteners. One 3"x2" area of MSA-2 was missing from the aft skirt acreage TPS near the 1926 ring frame between the -Y and +Z axes. The remaining material was slightly sooted (Figure 9).

All four Debris Containment System (DCS) plungers were seated. Approximately ten percent of the EPON shim material on both HDP #7 and #8 aft skirt support structure was missing prior to splashdown. The substrates were sooted/charred.

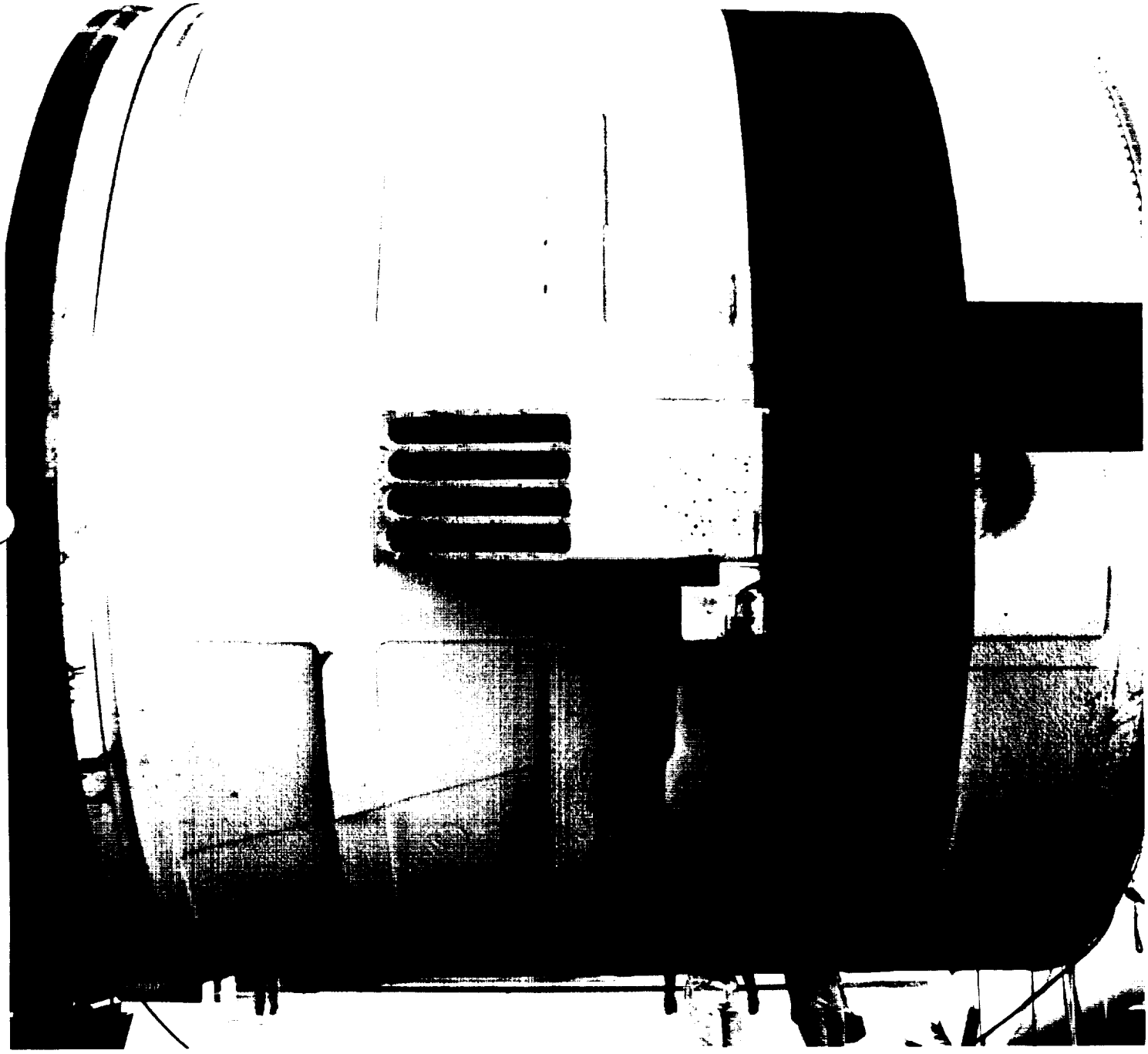
FIGURE 9. **LEFT SRB AFT SKIRT EXTERIOR TPS**



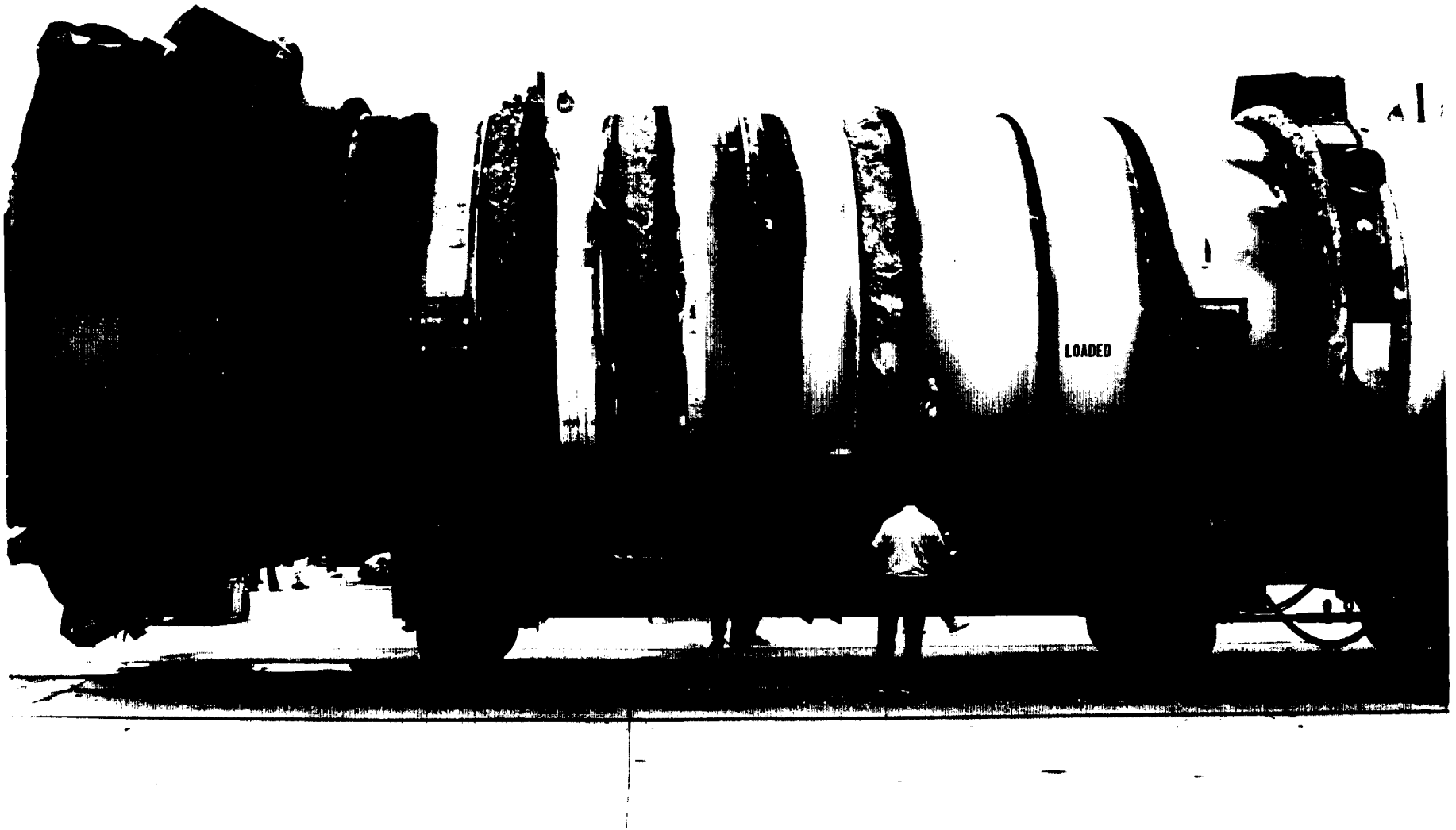
EGG/V-326F



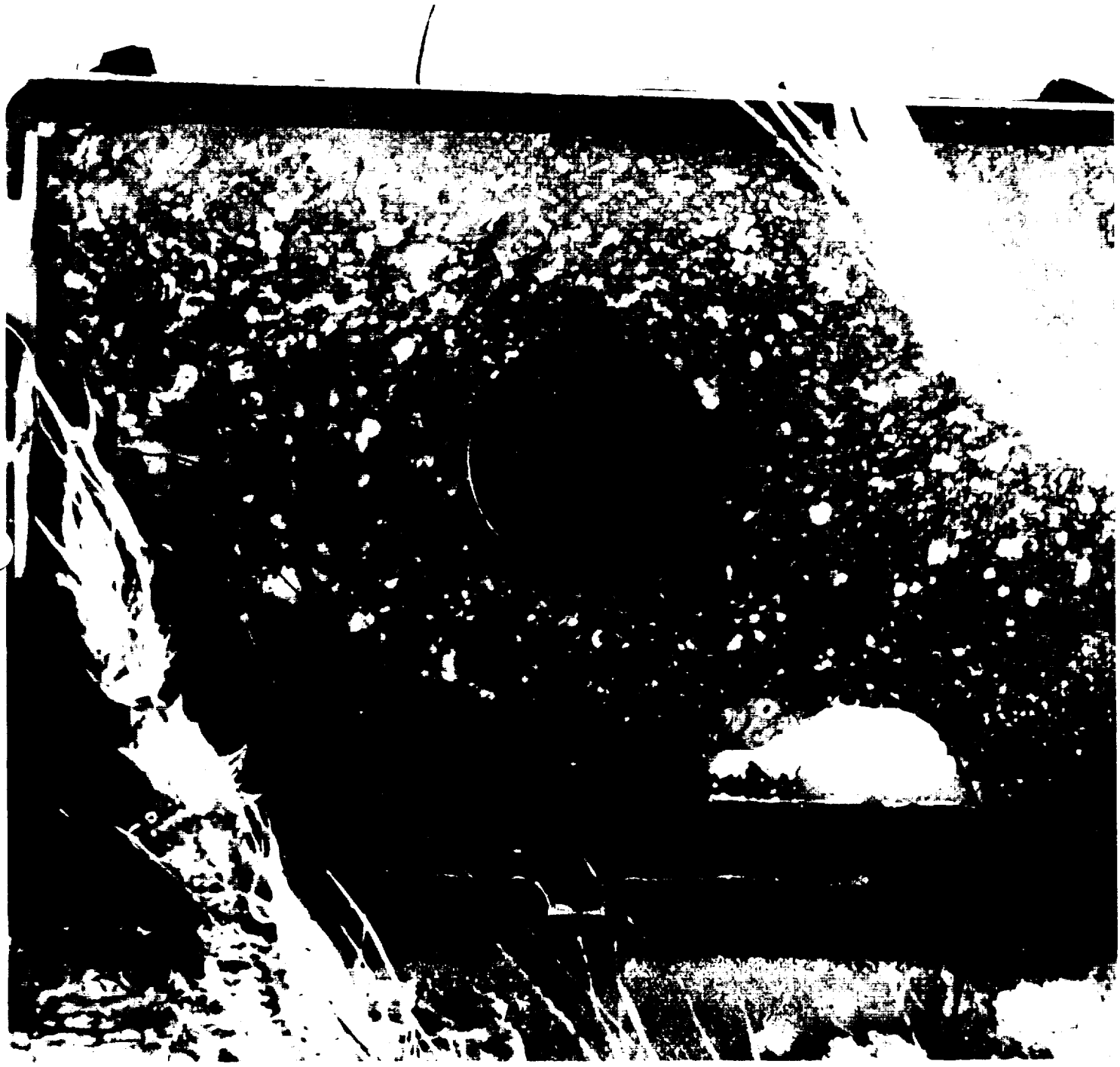
The LH frustum had a total of 27 MSA-2 debonds over fasteners. The BSM aero heat shield covers were locked in the fully opened position.



The LH forward skirt acreage MSA-2 exhibited no debonds or missing TPS. Both RSS antenna covers/phenolic base plates were intact.



Post flight condition of the LH aft booster and aft skirt. The ET/SRB aft struts, ETA ring, IEA, and IEA covers appeared undamaged. All three aft booster stiffener rings were damaged by water impact.



Approximately ten percent of the EPON shim material was missing prior to splashdown. The substrate was sooted.

7.3 RECOVERED SRB DISASSEMBLY FINDINGS

STS-57 was the sixteenth flight to utilize the new "optimized" frangible links in the holddown post DCS's. The link was designed to increase the DCS plunger velocity and improve the seating alignment while leaving the stud ejection velocity the same. The design was intended to prevent ordnance debris from falling out of the DCS yet not increase the likelihood of a stud hang-up. According to NSTS-07700, the Debris Containment System should retain a minimum of 90 percent of the ordnance debris.

A recent change to the disassembly procedures by SRB Project (DCN 009 10MNL-0035) eliminated the weighing of frangible nut pieces and ordnance fragments in the DCS containers unless: 1) debris is observed in the launch films; 2) the DCS plunger has an anomalous appearance during disassembly; or, 3) visual inspection of the expected DCS contents reveals the absence of any pieces.

High speed launch film showed the loss of two frangible nut pieces from the HDP #2 DCS at liftoff. Due to this anomaly, the contents of the DCS #2 housing was weighed. A total of 1.165 pounds of debris were lost sometime after launch.

HDP #	% of Nut without 2 Large Halves	% of Ordnance Fragments	% Overall
2	5	21	11

SRB Post Launch Anomalies are listed in Section 10.

FIGURE 10. **DEBRIS DAMAGE LOCATIONS**

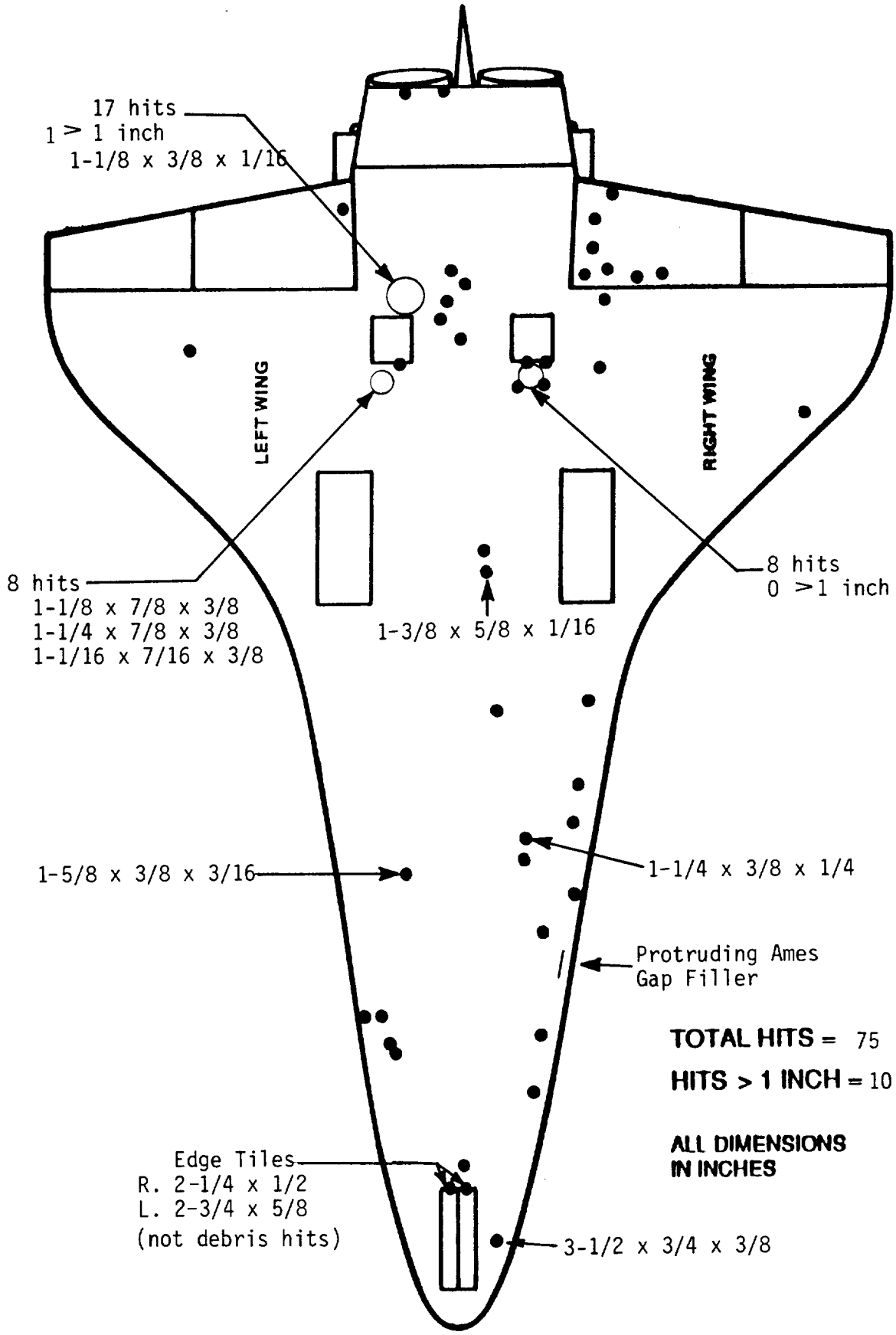
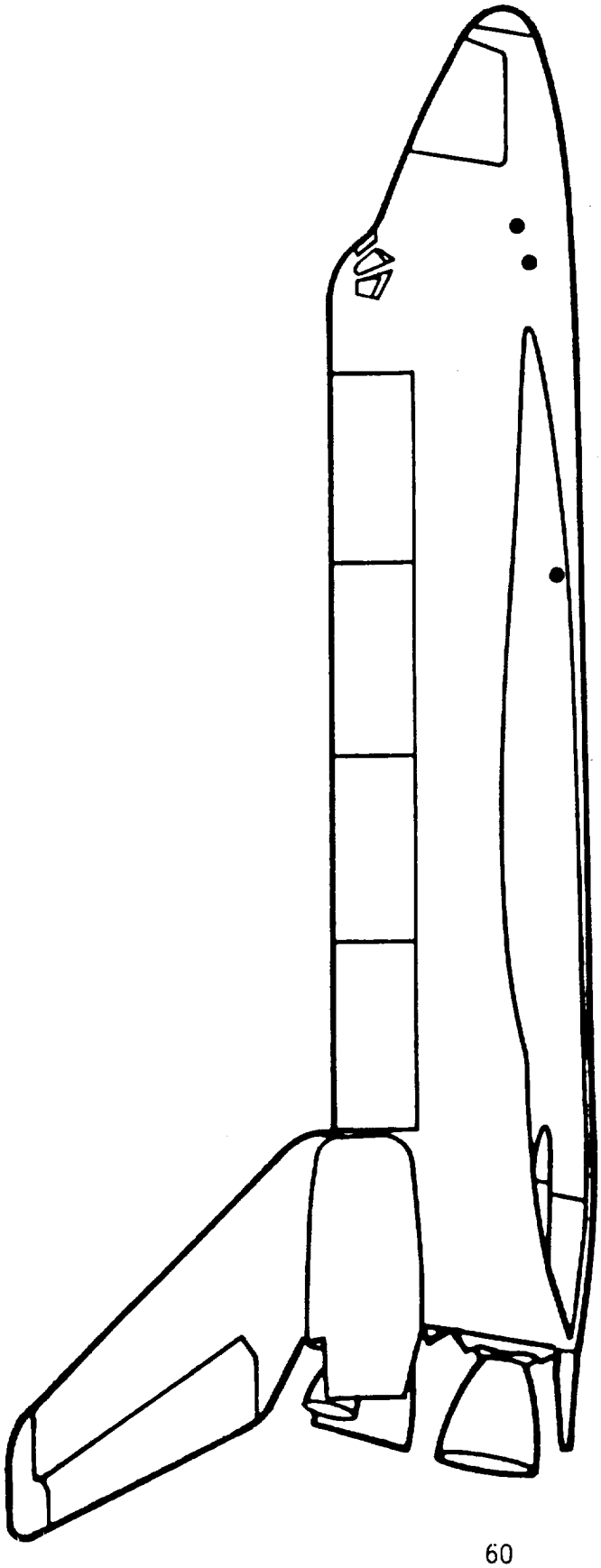


FIGURE 12

STS-57 DEBRIS DAMAGE LOCATIONS



TOTAL HITS = 3

HITS > 1 INCH = 0

No TPS damage was attributed to material from the wheels, tires, or brakes. The main landing gear tires were considered to be in good condition for a landing on the KSC runway.

ET/Orbiter separation devices EO-1 and EO-3 appeared to have functioned properly. The EO-2 debris plunger was obstructed by ordnance fragments. All ET/Orbiter umbilical separation ordnance retention shutters were closed properly.

A 15-inch long piece of LH2 ET/ORB umbilical foam with red silicone sponge purge seal, which should have remained with the ET during separation, adhered to the Orbiter half of the umbilical near the 4-inch flapper valve. Post landing analysis revealed the foam fractured during ET separation and concluded there was an inadequate RTV dam to prevent foam adherence to the curtain attach plate.

A 7/16" x 3/32" screw from the purge barrier retainer lay on the runway below the LH2 ET/ORB umbilical cavity. A nutplate with threads matching the screw was found wedged in a cavity on the ET door.

A piece of foam 3-inches long adhered to a tile on the RH ET door near the hinge line. The foam had been compressed into the thermal barrier when the door was closed, but apparently did not affect the seal during re-entry. According to post flight laboratory analysis, the foam did not match the External Tank acreage thermal protection system (TPS) CPR and was most likely MBO foam from the umbilical.

Orbiter windows #2, #3, #4, and #5 exhibited moderate hazing. Only a very light haze was present on the other windows. Some streaks were visible on windows #2, #3 and #4. Surface wipes were taken from all windows for laboratory analysis.

No samples were taken from tile damage sites or RCC panels.

Tile damage on the base heat shield was average. The SSME Dome Mounted Heat Shield (DMHS) closeout blanket sacrificial panels were intact, missing no material, and in excellent condition. One tile at the aft edge of the vertical stabilizer stinger was damaged by contact with the drag chute risers. A 2" x 1" piece of metal spring from the inside left surface of the rudder/speed brake was embedded in a vertical stabilizer stinger tile near the rudder hinge.

Runway 33 had been swept/inspected by SLF operations personnel prior to landing and all potentially damaging debris was removed.

The post landing walkdown of Runway 33 was performed immediately after landing. All Orbiter drag chute hardware was recovered. No organic (bird) debris or other hardware was found on the runway.

FIGURE 14. **STS-57 RCC TEMPERATURE MEASUREMENTS AS RECORDED BY THE SHUTTLE THERMAL IMAGER**

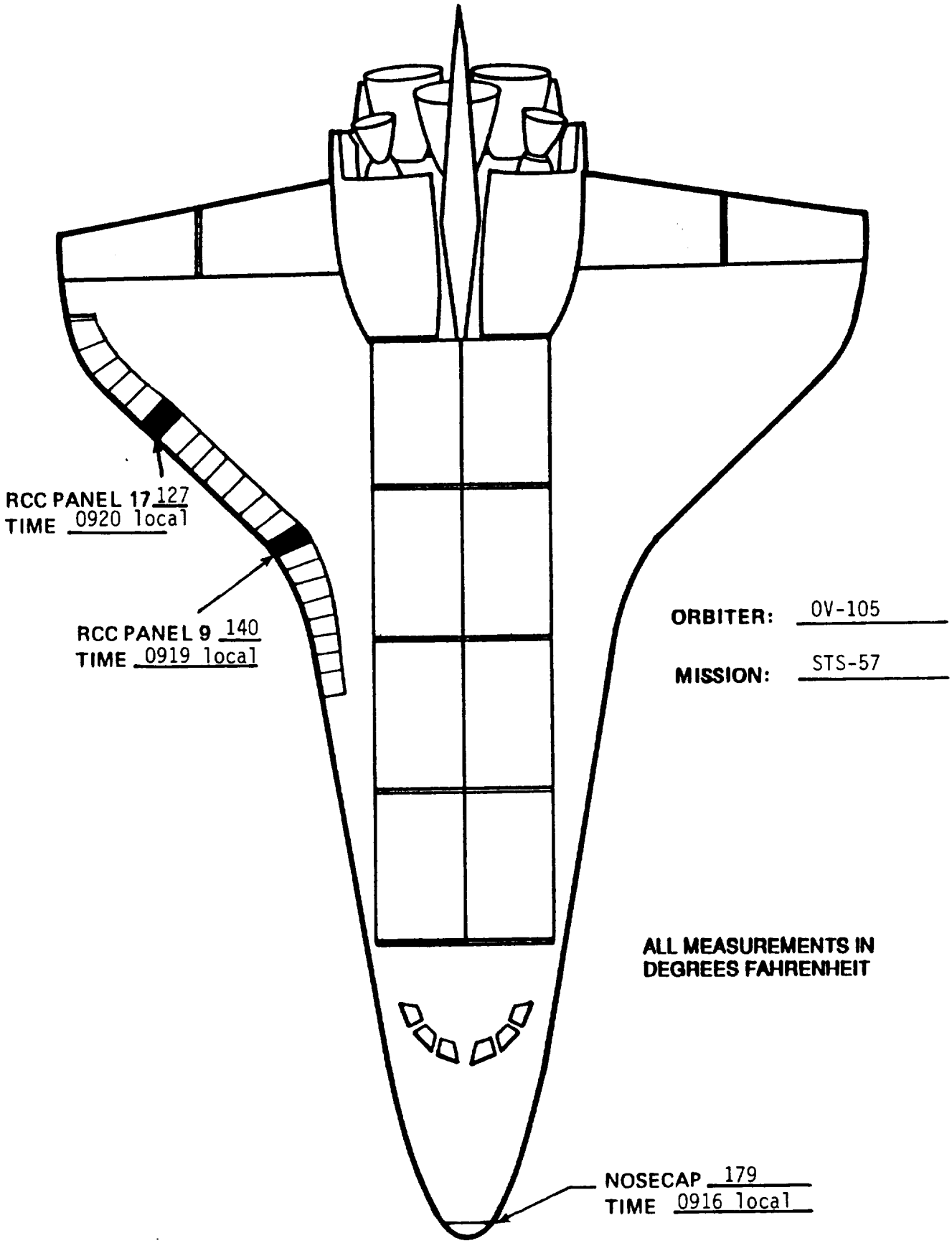
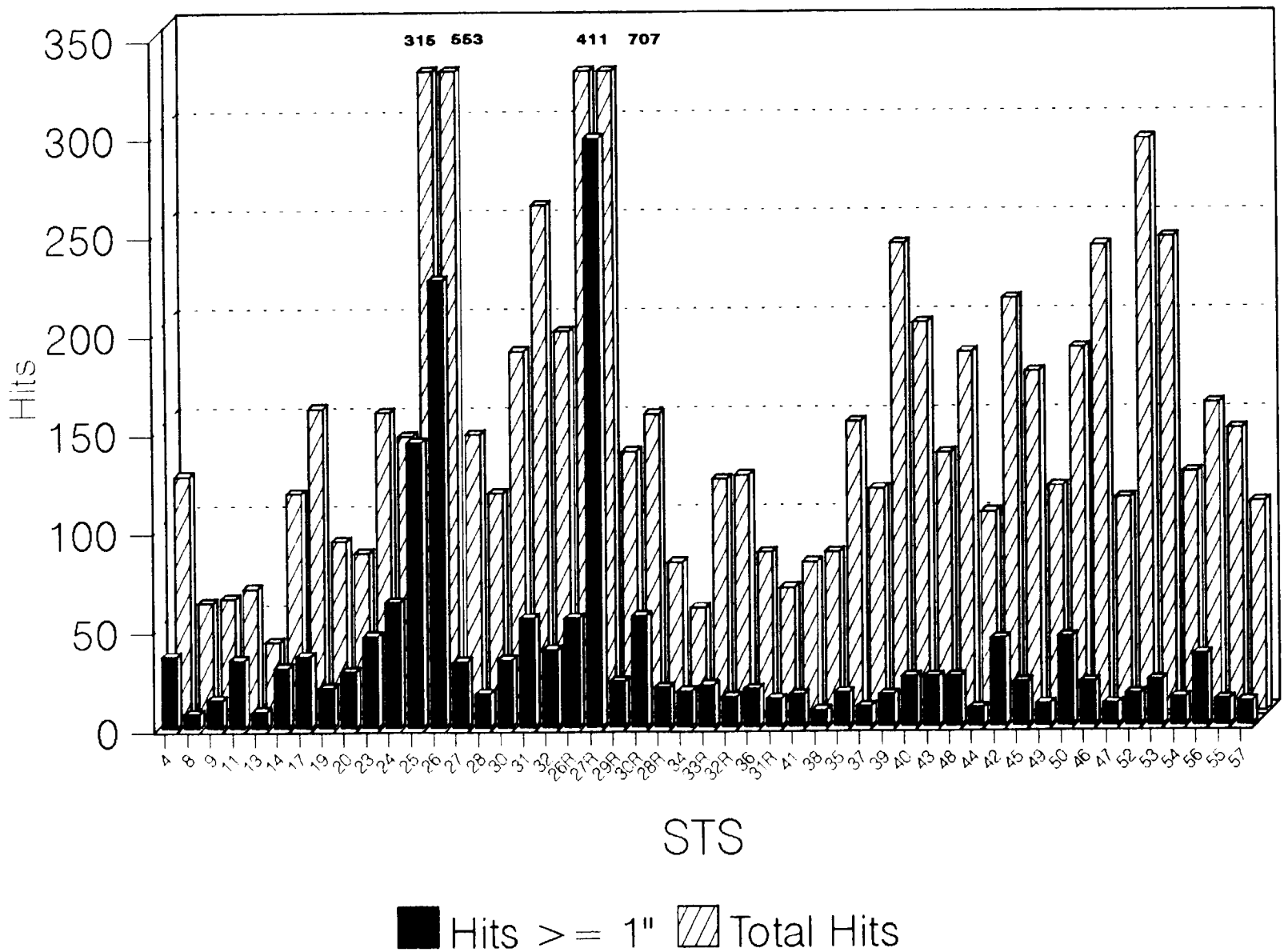
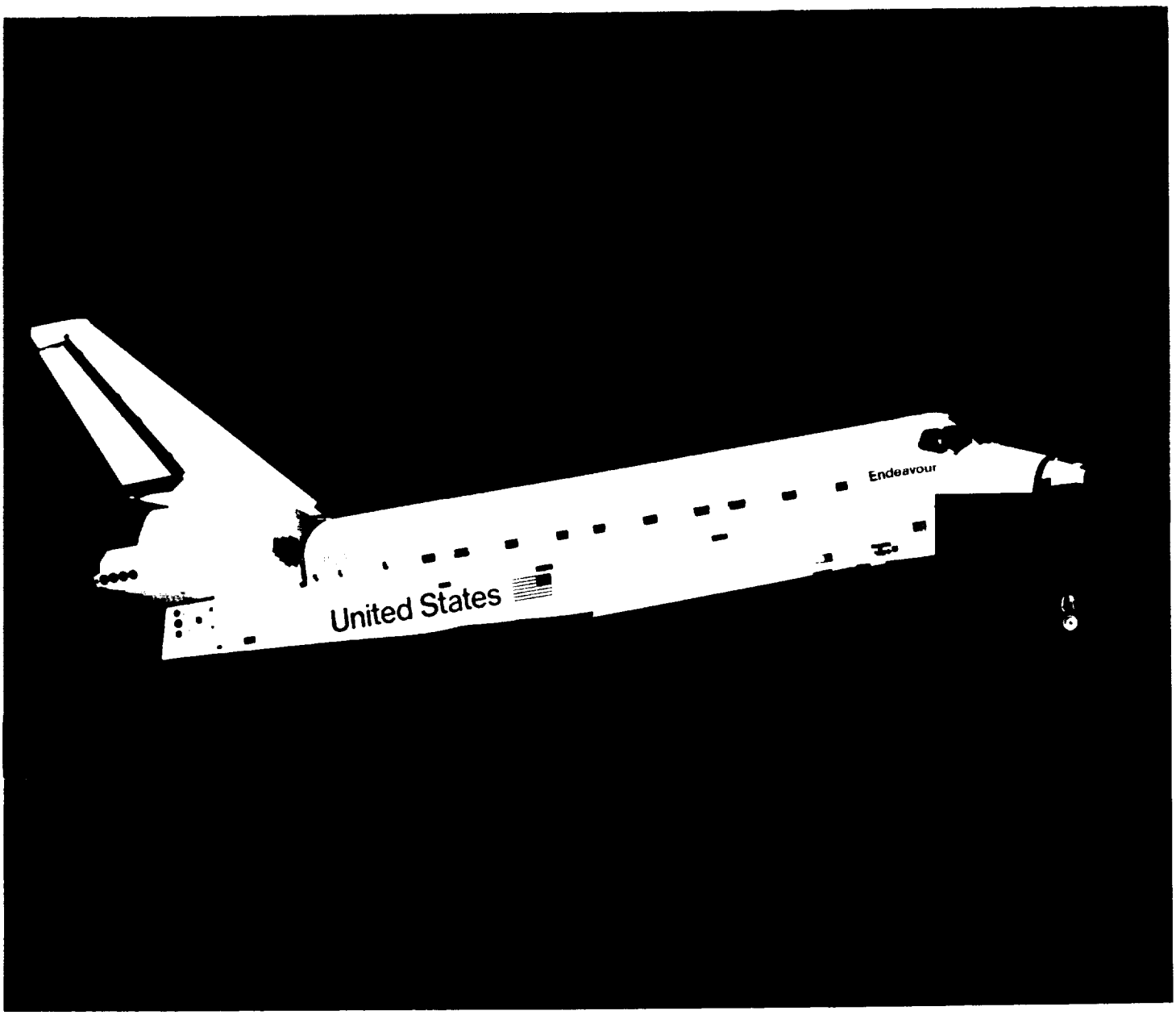
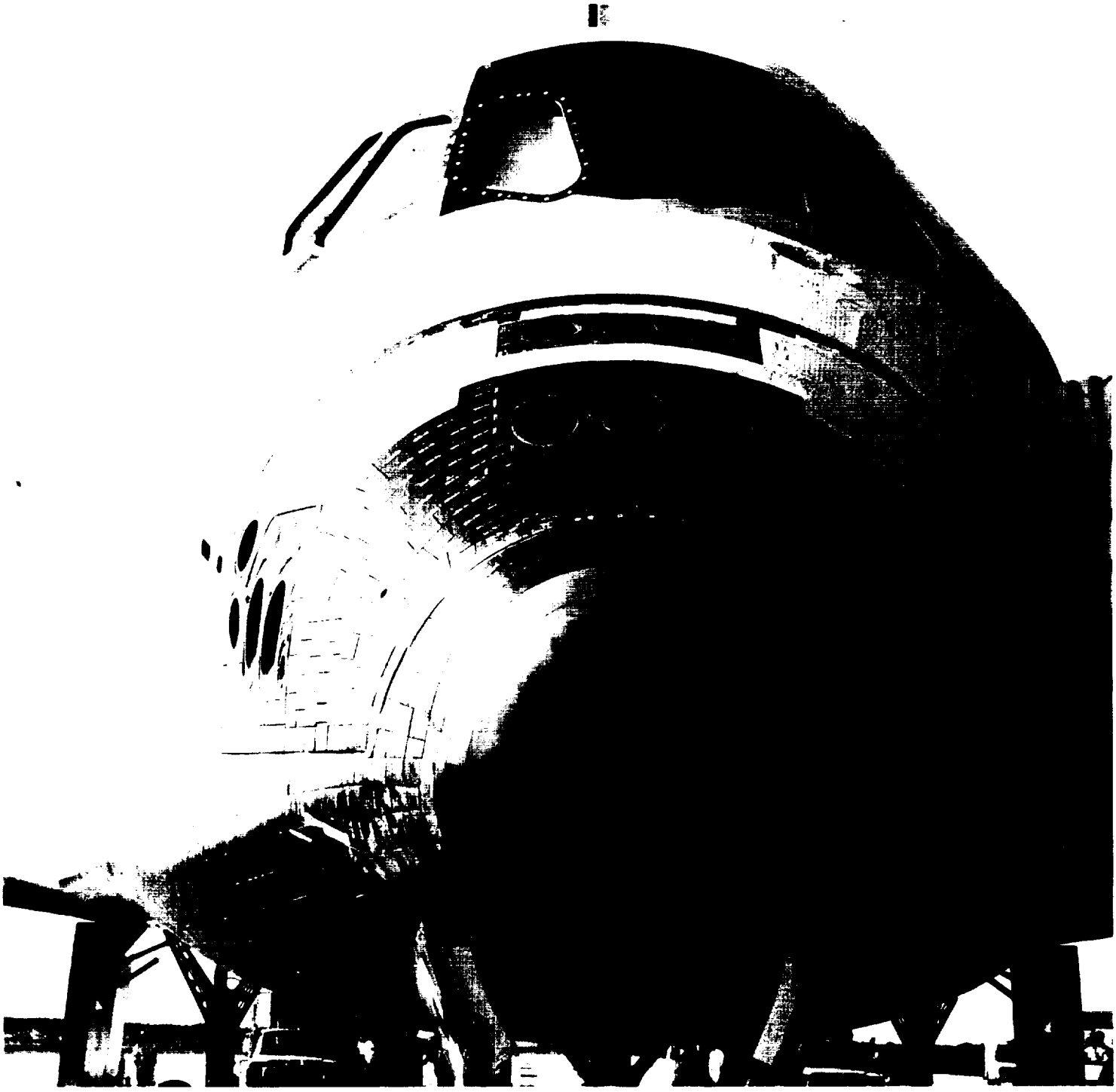


FIGURE 16. # COMPARISON TABLE



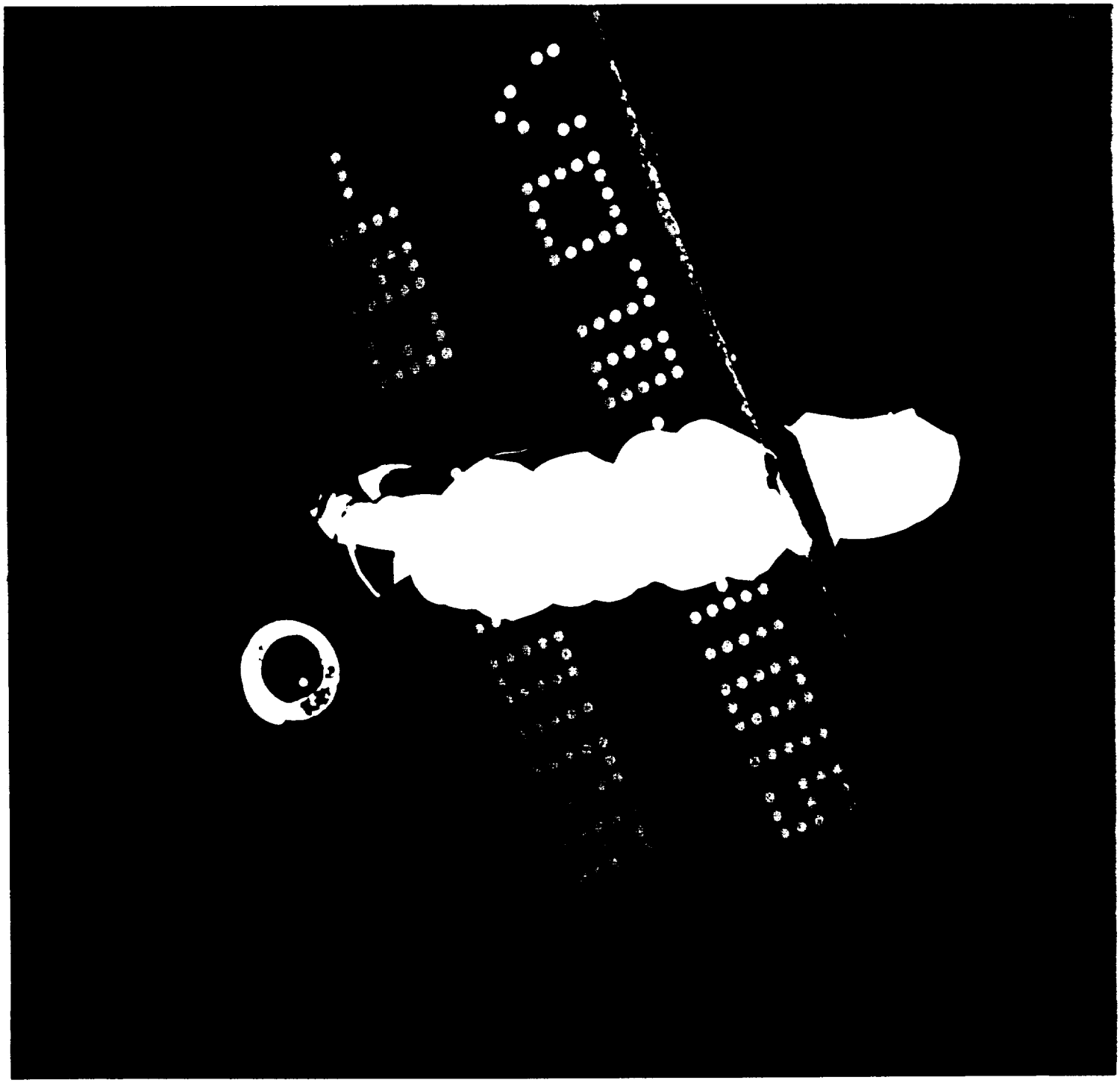


Overall view of OV-105 right side. Endeavour made the 16th KSC landing on Runway 33 on 1 July 1993.

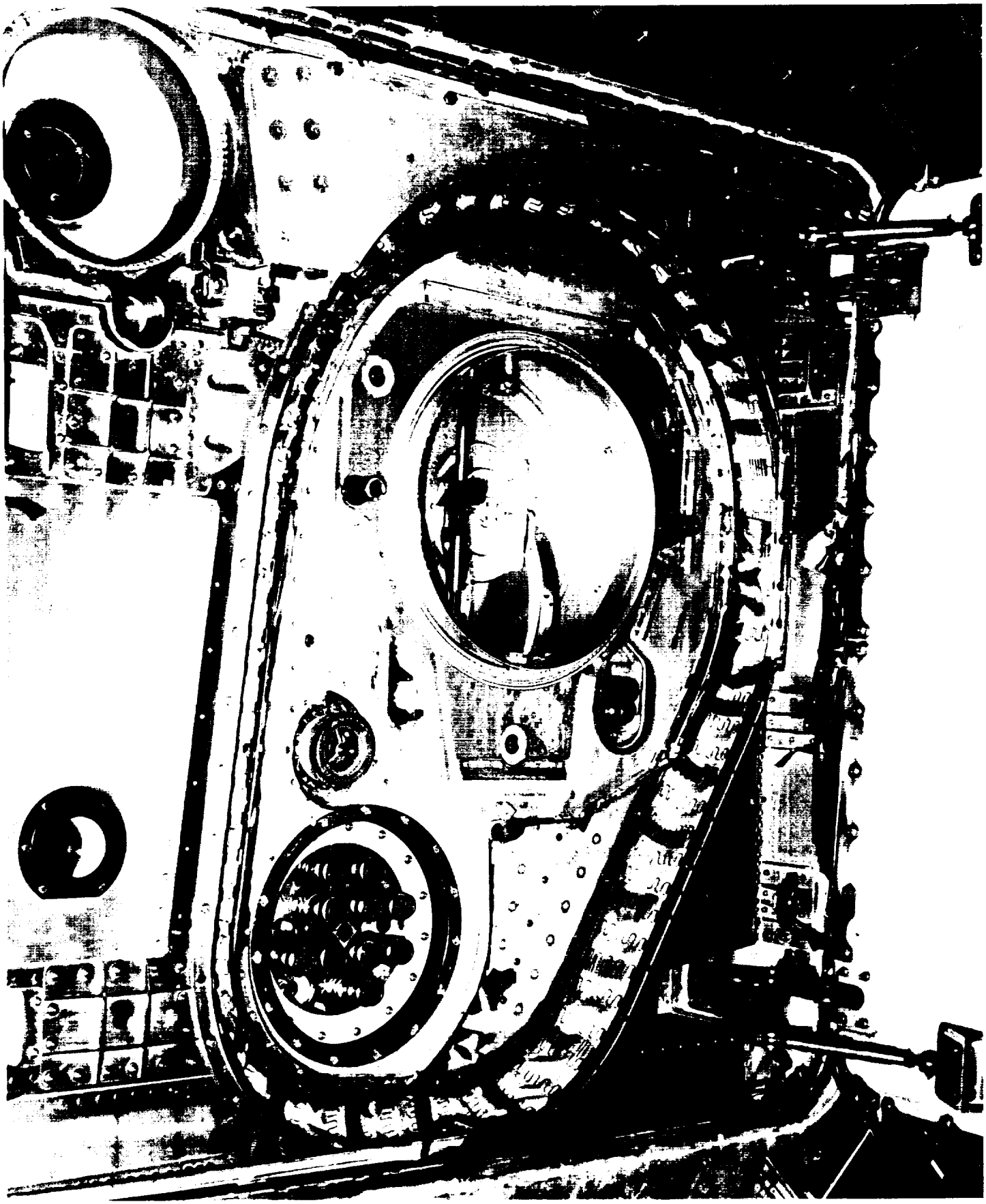


Overall view of the Orbiter nose. Forward facing windows were moderately hazed. Note discoloration of the AFRSI near the F3D and F1F thrusters.

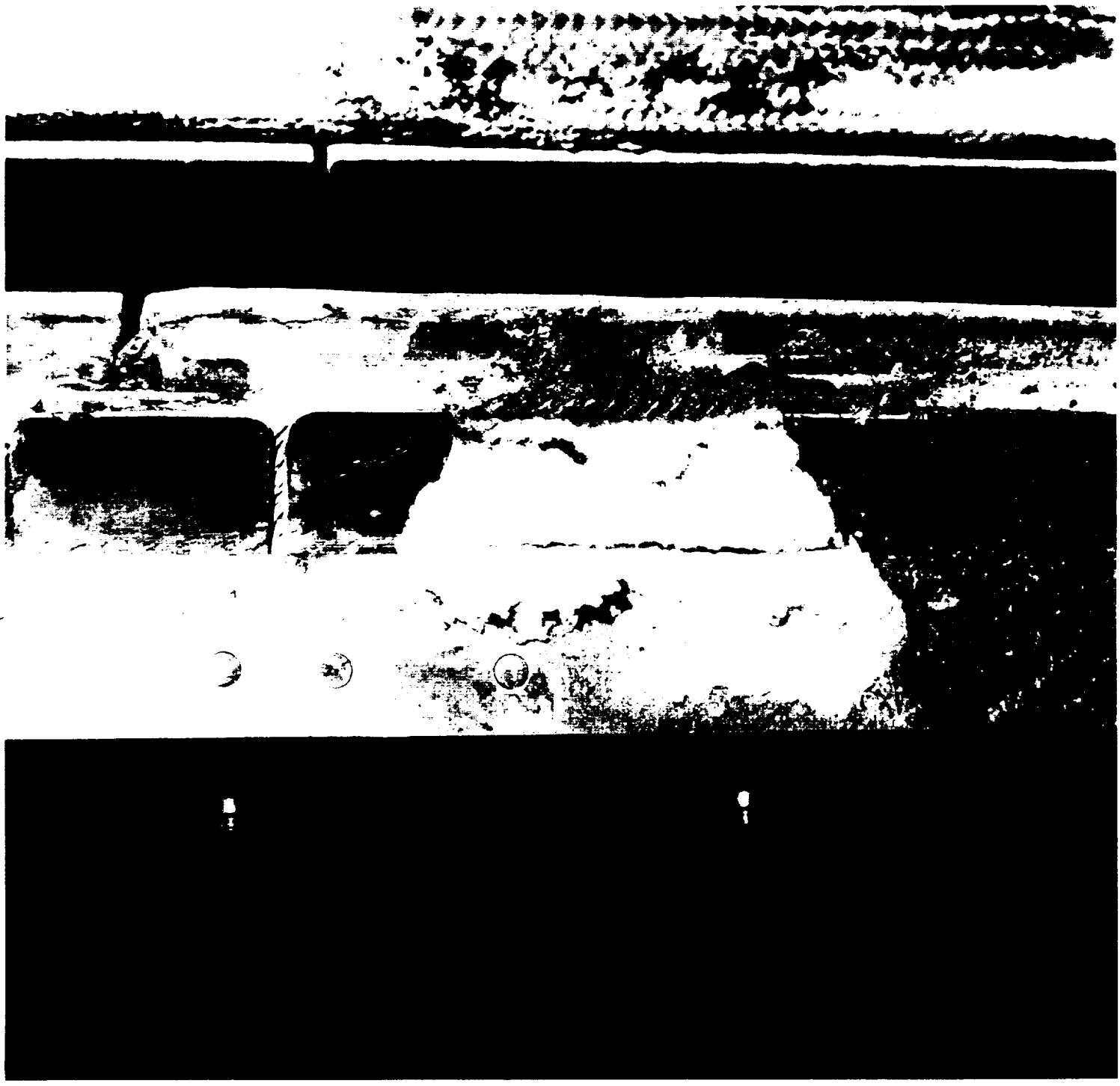
Tile damage on the base heat shield was average. The SSME Dome Mounted Heat Shield (DMHS) closeout blanket sacrificial panels were intact and missing no material.



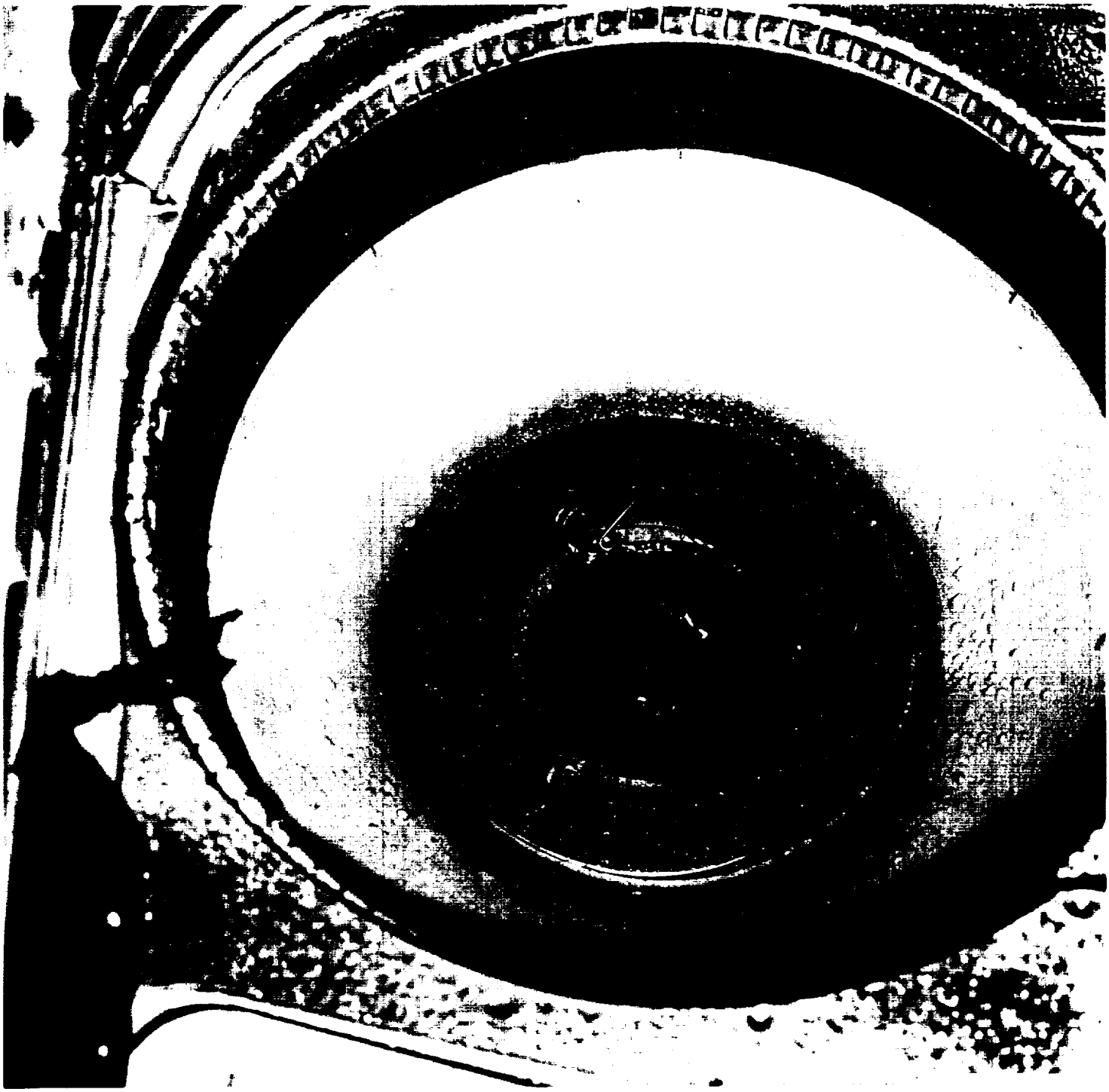
The Orbiter lower surface sustained a total of 75 hits. The largest tile damage site measured 3.5" x 0.75" x 0.375" and was located on the RH lower surface outboard of the nose landing gear door.



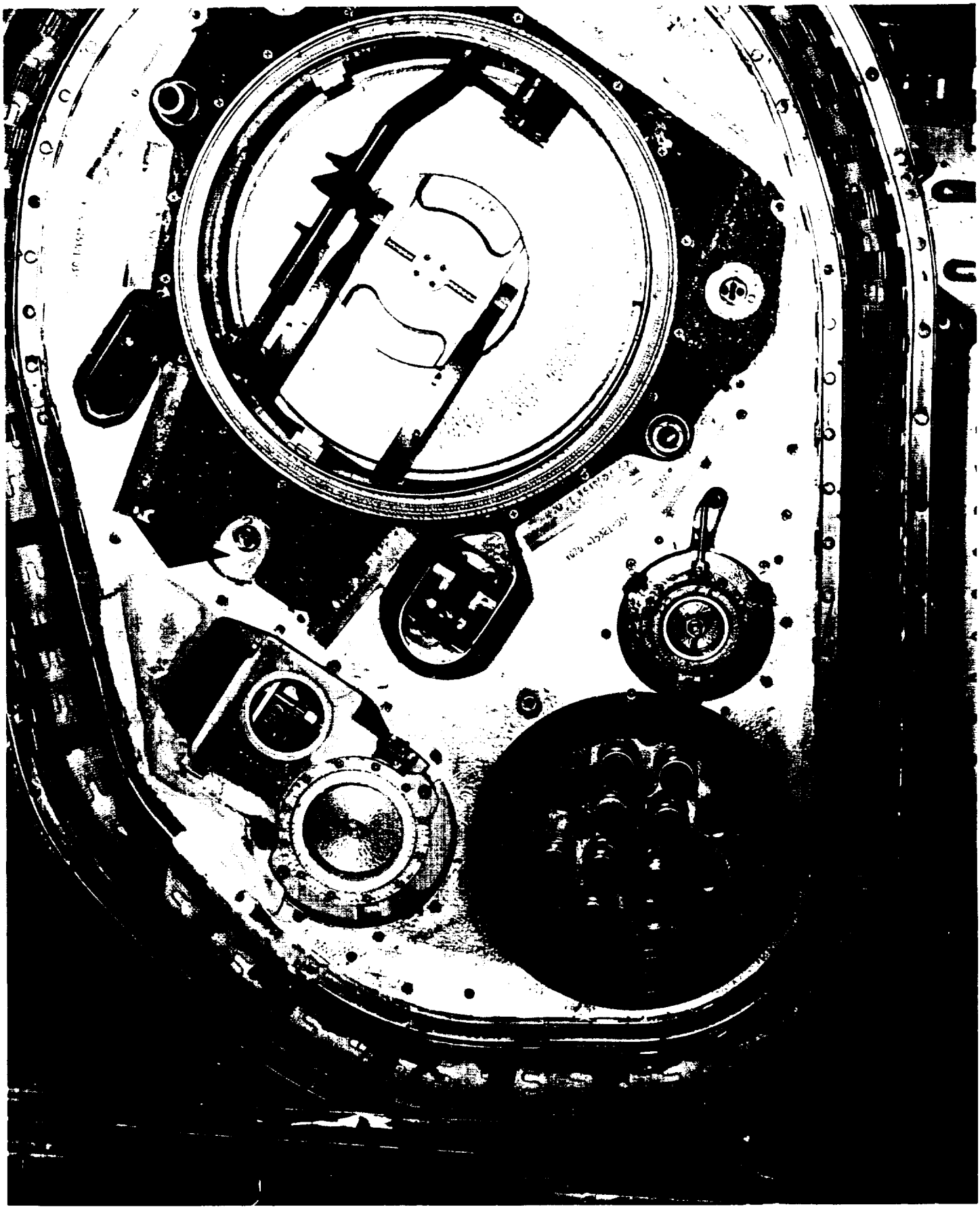
Overall view of the LO2 ET/ORB umbilical. All separation ordnance devices functioned properly. No flight hardware was found on the runway below the umbilical when the ET door was opened.



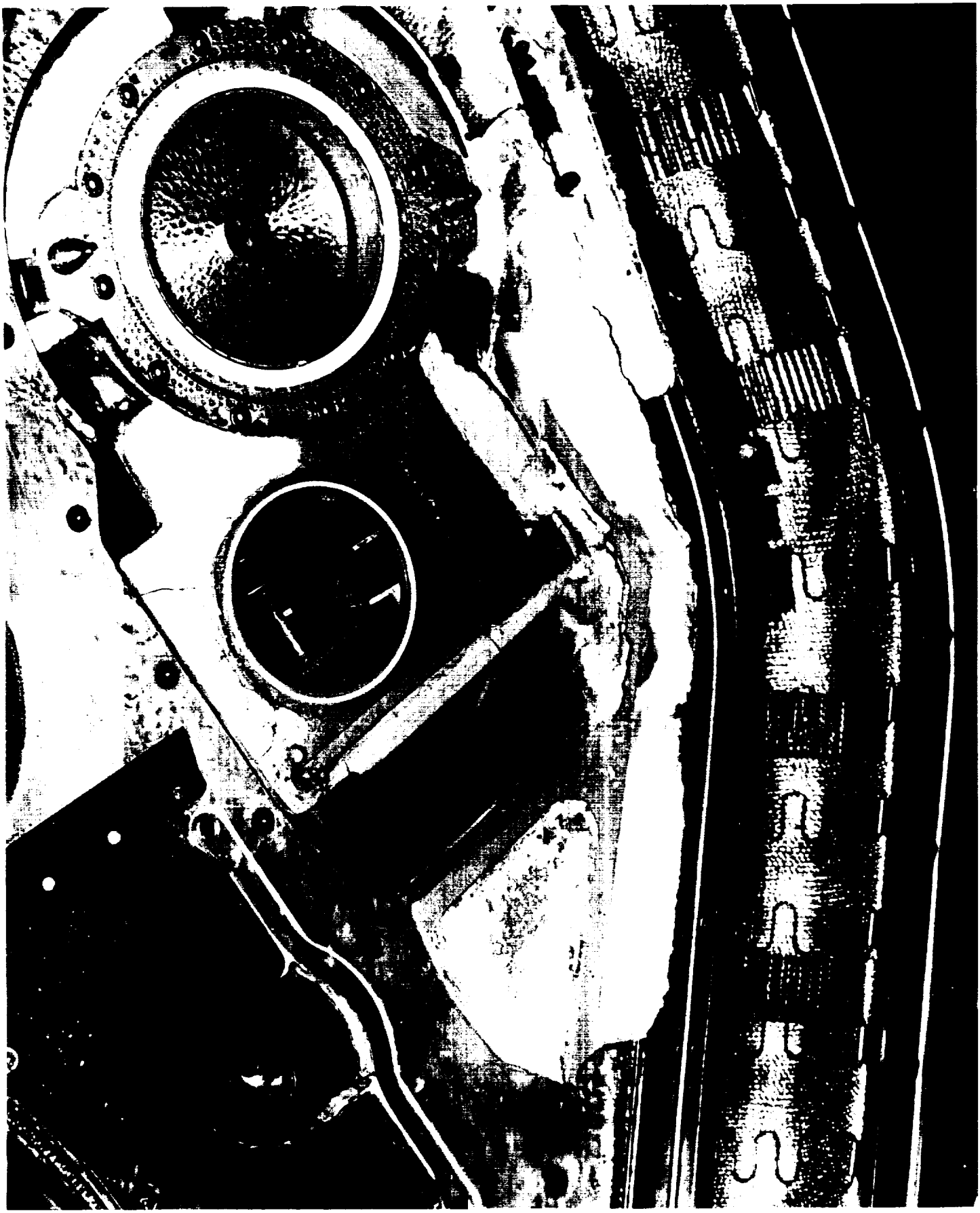
Visual inspection of the right ET door (LO2 side) revealed a 3" x 1" piece of foam adhering to a tile near the hinge line. The foam had been compressed into the thermal barrier when the door was closed, but apparently did not affect the seal.



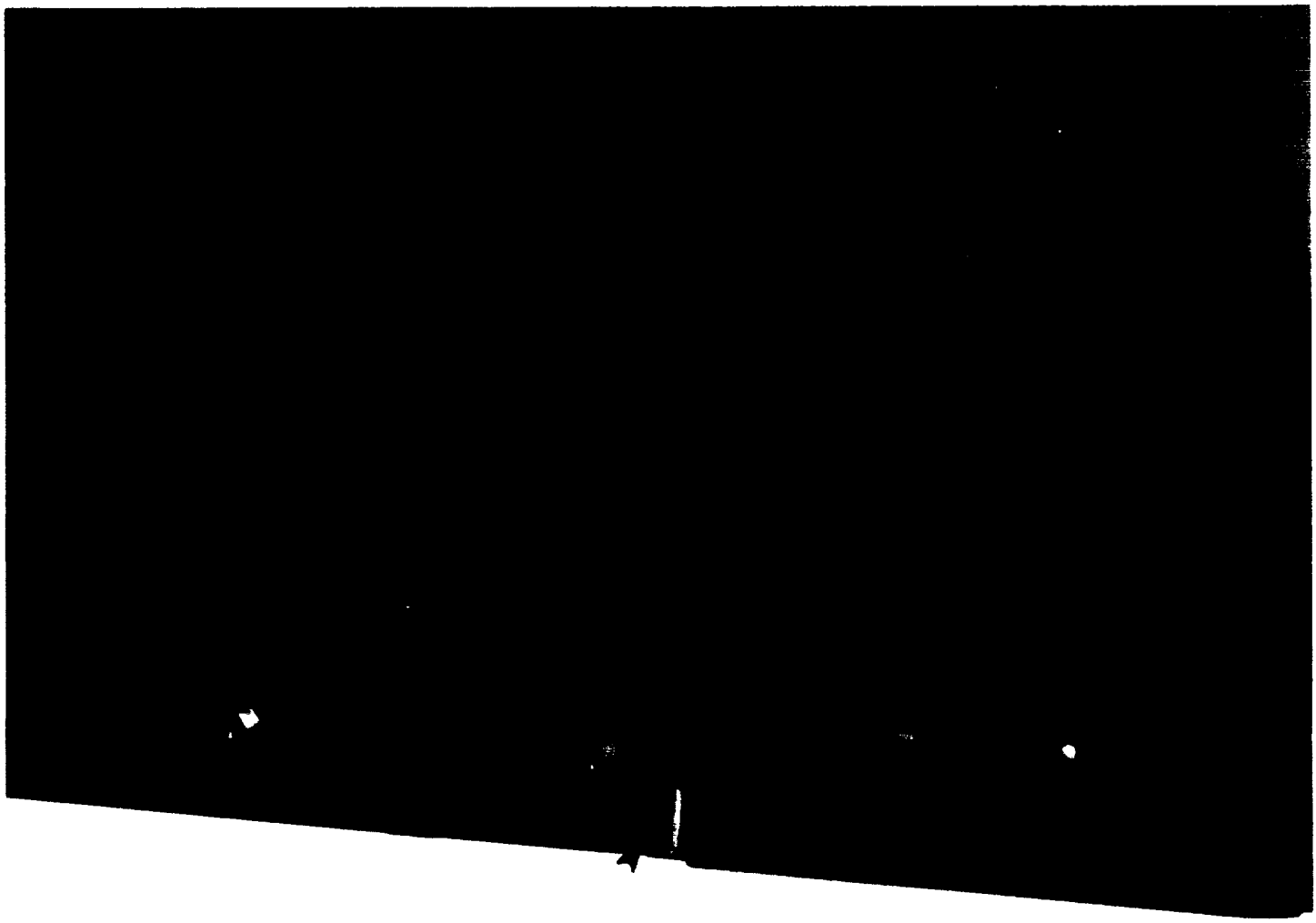
The left ET/ORB attach point (EO-2) hole plugger had not seated and was obstructed by ordnance fragments



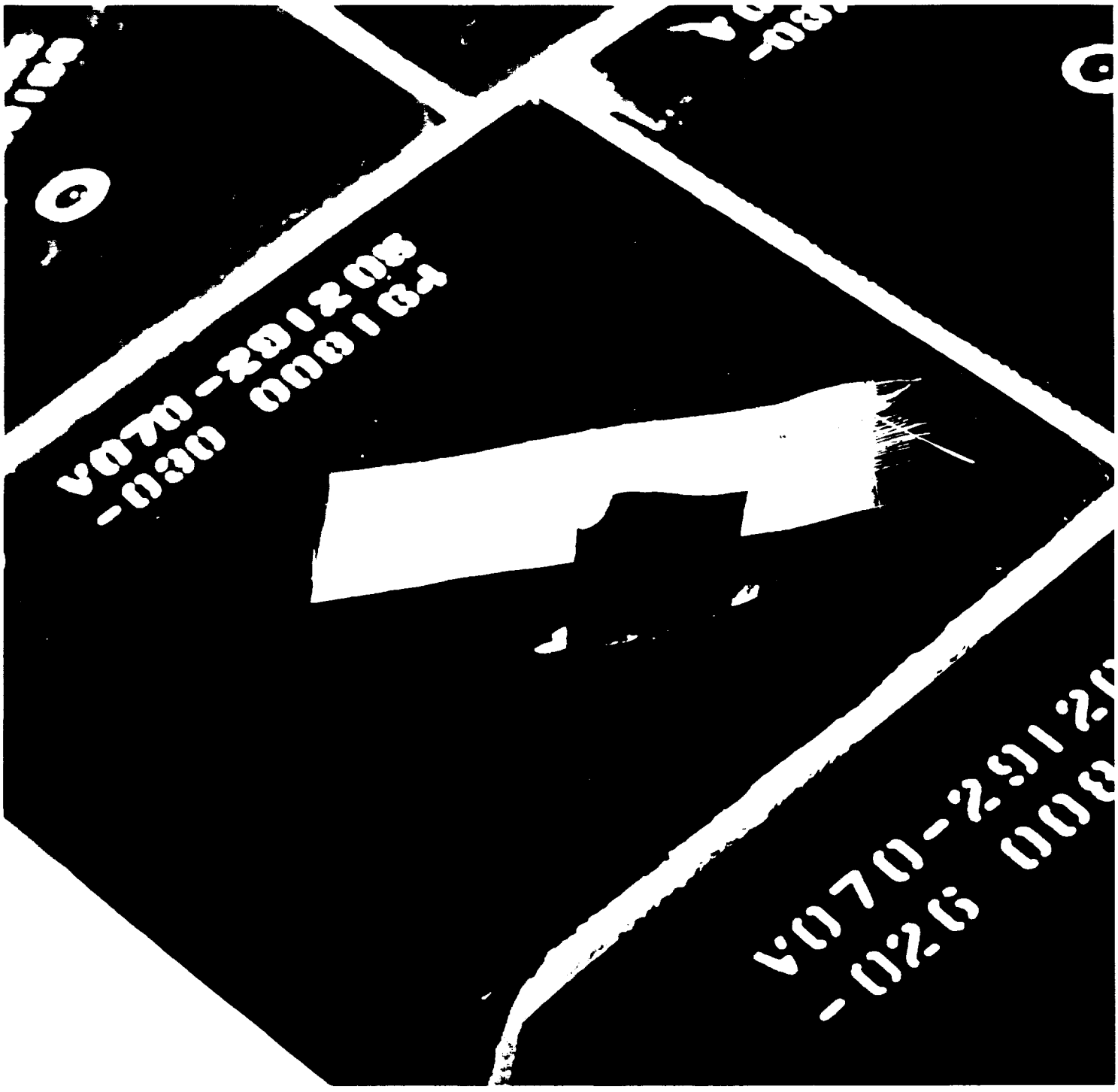
Overall view of the LH2 ET/ORB umbilical. All separation ordnance devices functioned properly. Note piece of umbilical foam adhering to the plate adjacent to the 4-inch disconnect.



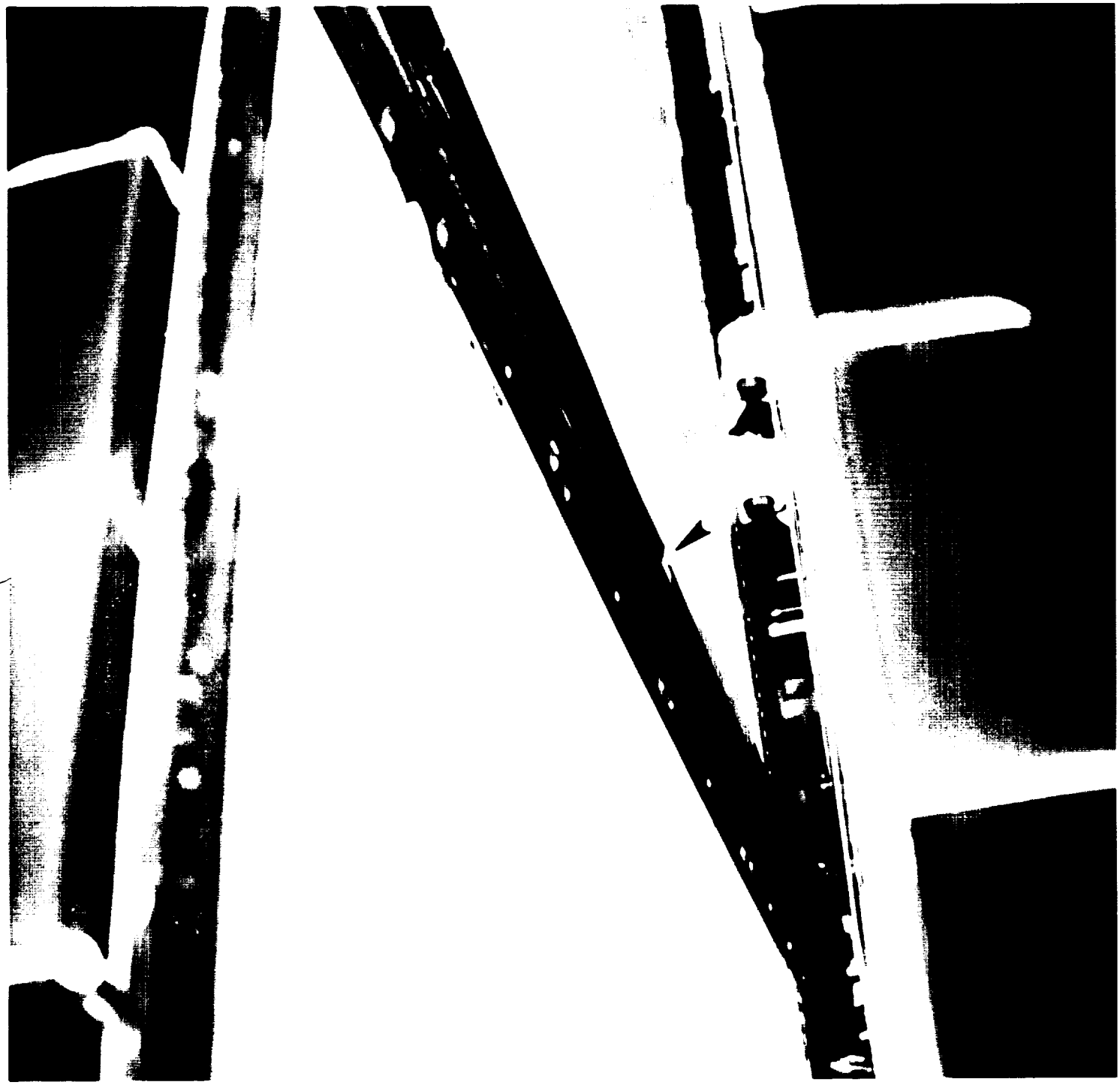
A 15-inch long piece of foam with red purge seal, which should have remained with the ET during separation, adhered to the LH2 ET/ORB umbilical near the 4-inch flapper valve.



A small screw from the purge barrier retainer was found on the runway below the LH2 ET/ORB umbilical cavity. A nutplate with threads matching the screw, shown here, was wedged in a cavity on the left ET door.



A 2" x 1" piece of metal spring was embedded in a tile on the vertical stabilizer stinger near the hinge



The piece of metal spring originated from the inside surface of the rudder/speed brake left panel

9.0 DEBRIS SAMPLE LAB REPORTS

A total of eight samples were obtained from OV-105 Endeavour during the STS-57 post landing debris assessment at the Kennedy Space Center. The submitted samples consisted of 8 window wipes (Windows 1-8). The samples were analyzed by the NASA KSC Microchemical Analysis Branch (MAB) for material composition and comparison to known STS materials. Debris analysis involves the placing and correlating of particles/residues with respect to composition, thermal (mission) effects, and availability. The debris sample result summaries are given by Orbiter location in the following paragraphs and shown in tabular form in Figure 17.

Orbiter Windows

Samples from the Orbiter windows indicated exposure to SRB BSM exhaust (metallics, aluminum and ferrous corrosion), Orbiter Thermal Protection System (RTV, tile, insulation, tile filler), paints and primer from various sources, landing site products (alpha-quartz, calcite), window polish residue, and organic materials. A finding that has been previously observed (STS-50 vertical stabilizer sample, STS-56 and STS-55 window samples) was the presence of "E-glass". Trace amounts of yellow paint were found in all of the 8 window samples and was attributed to facility/ground support equipment paint. Final results of the organic material analysis are still pending. There was no apparent vehicle damage related to any residual finding.

STS-55 Organic Analysis

The final results of the STS-55 organic analysis are also shown in this report. Types of identified materials included those associated with window covers (plastic polymers, foam/adhesive, rubber), RTV, and cellulosic (sample cloth). This variety of residuals, which were attributed to known sources, did not change significantly when compared to previous sample data (reference Figure 17). No new findings were found in this analysis.

New Findings

This sampling set provided two new findings in debris residual post-flight samples. These new findings were obtained from the window samples and did not appear related to any debris damage problem. A building type of insulation and a possible teflon particle were detected. Additional testing is continuing to identify and isolate the source for these findings.

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
47	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics-Fibrous mat'l,red RTV Organics-filled rubber,plastic polymers Paint		Silica-rich Tile (ORB TPS)		
46	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite,Alpha-Quartz,Salt(Landing Site) Organics-Adhesive,Foam,red RTV Organics-filled rubber,plastic polymers Paint				Crew Hatch Window - Metallics - BSM Residue (SRB) - Alpha-Quartz, Salt (Landing Site) - RTV, Tile (ORB TPS) - Paint - Organics
50	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Window Polish Residue (ORB) Mica, Calcium, Salt (Landing Site) Organics-Adhesive,Foam Organics-Plastic Polymers Paint		Silica-Rich Tile (ORB TPS)		Orbiter Vertical Stabilizer - Tile Coating (ORB TPS) - Structural Coating Glass "E-Glass"
49	Metallics - BSM Residue (SRB) RTV. Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Calcium, Salt (Landing Site) Organics Paint	RTV, Tile (ORB TPS) Rust - BSM Residue (SRB) Muscovite, Salt (Landing Site) Organics Paint	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Rust - BSM Residue (SRB) Calcium Mat'l,Salt (Landing Site Soil) Organics Paint		
45	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint		Iron - Rich Mat'l Paint		
42	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Muscovite (Landing Site) Organics Paint		Metallics - BSM Residue (SRB) Tile, Tile Coating (ORB) Salt (Landing Site) Paint	Organics	RH Fuselage - Tile Coating (ORB)

Figure 17. Post Landing Orbiter Microchemical Sample Results

STS	Sample Location				
	Windows	Wing RCC	Lower Tile Surface	Umbilical	Other
35	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Window Polish Residue (ORB) Organics Paint	Metallics - BSM Residue (SRB) RTV, Tile (ORB) Organics	RTV, Tile (ORB TPS) Metallic - Rust, Aluminum Welding Slag (Facility)		
38		RTV, Tile (ORB TPS) Hypalon Paint (SRB) Ensolite Foam (RCC Prot. Cover)	Tile (ORB TPS)		
41	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics	Tile (ORB TPS) Salt (Landing Site)	Tile (ORB TPS)	Calcite (Landing Site) Fluorocarbon (Viton-ORB Umb) Foam (ORB C/O)	Fwd FRSI - Silicon Mat'l (ORB TPS)
31R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Calcite, Salt (Landing Site) Organics	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Organics Foam Insulation (ET/SRB) Paint	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Paint		
36	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Salt (Landing Site) Paint	Rust - BSM Residue (SRB) Tile (ORB TPS) Paint Organics	RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica (Landing Site) Organics Microballoon (ET/SRB)	Rust - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Microballoon (ET/SRB) Calcite (Landing Site) Foam, Organics (ORB Umb C/O)	
32R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Salt (Landing Site) Paint		Metallics - BSM Residue (SRB) Tile (ORB TPS) Carbon Fibers Titanium	Metallics - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Phenolic Microballoon (ET/SRB) Quartz, Calcite (Landing Site) Organics	
33R	Metallics - BSM Residue (SRB) RTV, Tile (ORB TPS) Insulation Glass (ORB TPS) Micaceous Mat'l, Salt (Landing Site) Window Polish Residue (ORB) Paint	Metallics - BSM Residue (SRB) Tile (ORB TPS) Insulation Glass (ORB TPS) Mica, Spar, Salt (Landing Site) Organics	RTV, Tile (ORB TPS)	Rust - BSM Residue (SRB) RTV, Insulation Glass (ORB TPS) Phenolic Microballoon (ET/SRB) Paint Organics	Crew Hatch Window - Rust - BSM Residue (SRB) - Alpha Quartz (TPS/Landing Site) - Paint - Organics

Figure 17. Post Landing Orbiter Microchemical Sample Results

10.0 POST LAUNCH ANOMALIES

Based on the debris walkdowns and film/video review, 17 post launch anomalies, including six IFA candidates, were observed on the STS-57 mission.

10.1 LAUNCH PAD/SHUTTLE LANDING FACILITY

1. Three metal items (1-3/8" x 1/4" bolt, 5/8" x 1/4" bolt, 7/8" diameter washer) lay on the MLP deck near HDP #8 between the sound suppression water pipe and SRB exhaust hole.

2. The cable attached to the J2 electrical connector on the GUCP appeared to have excessive slack, which caused the cable to momentarily catch on a intertank access platform hand rail during retraction.

10.2 EXTERNAL TANK

1. At least 70 small divots, 3-4 inches in diameter, occurred on intertank stringers forward of the bipods. Seven small divots were visible in the LH2 tank-to-intertank flange closeout between the bipods.

2. Nine divots, 6-8 inches in diameter, occurred along a line on the -Y thrust panel on the +Z side of the EB fitting. As many as nine smaller divots were scattered on the -Y thrust panel on the -Z side of the EB fitting (IFA candidate).

3. A divot, 6-8 inches in diameter, was present in the -Y (LH) longeron closeout.

4. Foam was missing from the +Y thrust strut flange and primer/ metal substrate was exposed.

5. The lightning contact strip was missing from the top of the LO2 ET/ORB umbilical (IFA candidate).

6. Red purge seal was missing from the LH2 ET/ORB umbilical near the 4-inch disconnect (still attached to the Orbiter after landing) and at the top outboard section. A piece of white RTV drifting by the camera lens may also have originated from the top outboard section. TPS damage had occurred on the inboard side of the umbilical and a large piece of foam, which measured approximately 2 feet long by 4 inches wide by as much as 1 inch thick, had partially separated from the umbilical. TPS on the top surface of the umbilical had peeled back in two places. (IFA candidate).

Appendix A. JSC Photographic Analysis Summary

August 6, 1993

Greg Katnik
MC/TV-MSD-22
OSB Room 5203R
KSC, Florida 32899

Dear Greg,

The following Summary of Significant Events report is from the Johnson Space Center NSTS Photographic and Television Analysis Project, STS-57 Final Report, and was completed August 6, 1993. Publication numbers are LESC-30783 and JSC-25994-57. The actual document can be obtained through the LESC library/333-6594 or Christine Dailey /483-5336 of the NSTS Photographic and Television Analysis Project.

Christine Dailey, Project Specialist
Photo/TV Analysis Project

2.1.2 Debris Near the Time of SRB Ignition

2.1.2.1 Debris from DCS at HDP M-2
(Camera E-8)

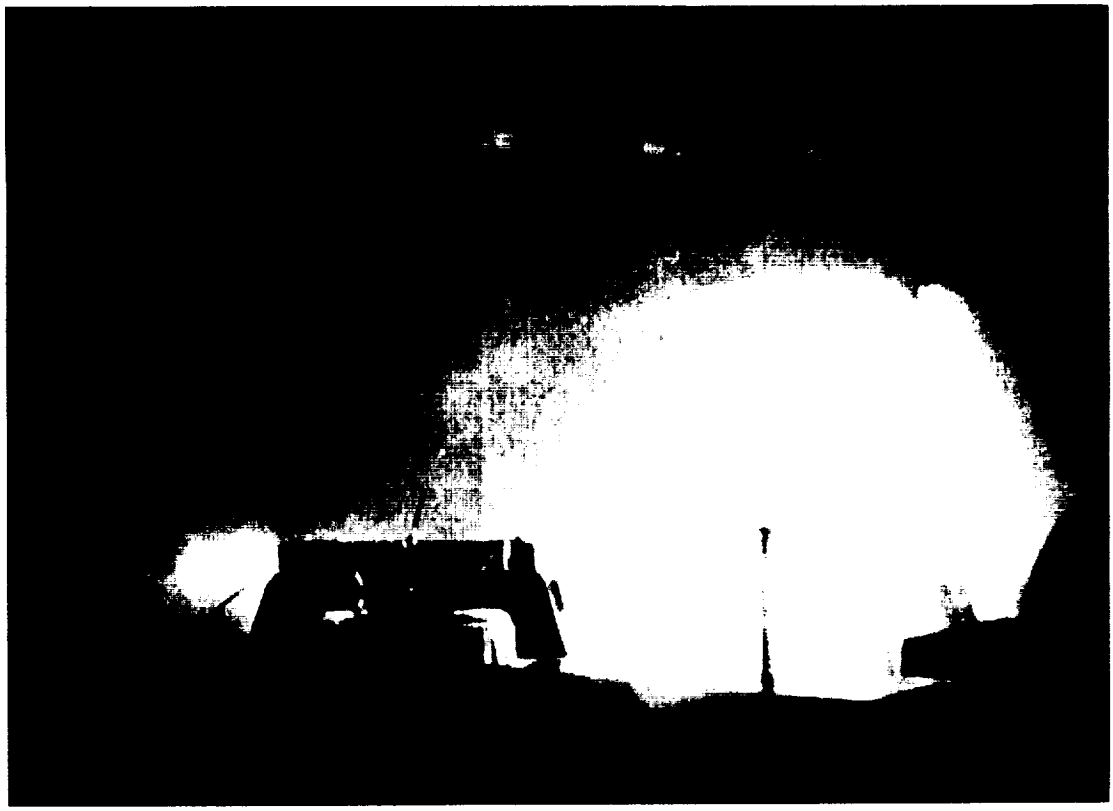


Figure 2.1.2.1 Metallic Debris from DCS Stud Hole of the RSRB HDP M-2

A metallic appearing piece of debris (see Figure 2.1.2.1) was noted to fall from the DCS stud hole of the RSRB holddown post M-2 at liftoff (13:07:23.048 UTC).

2.1.2.2 Debris near SRB HDPs at SRB Ignition
(Cameras E-7, E-8, E-11, E-13)

A small dark piece of debris came from behind the holddown post M-4 DCS and another dark piece of debris came from behind the east side of the LSRB holddown post M-6 DCS at liftoff (13:02:22.000 UTC). Another single small dark piece of debris was noted near LSRB holddown post M-7 DCS area. The debris possibly originated from the DCS area. None of the DCS debris described appeared to strike the vehicle.

A small flat dark piece of debris appeared to move toward and contact the outer surface of the RSRB support structure (foot) of holddown post M-2 (13:07:18.959 UTC). No damage was visible from the contact.

2.1.2.3 SRB Flame Duct Debris *(Task #7)* *(Cameras E-8, E-11, E-12, E-15, E-26)*

As on previous missions, several pieces of debris were noted originating from the Solid Rocket Booster (SRB) flame duct area after SRB ignition. The SRB flame duct debris seen on STS-57 was not significant and required no analysis.

2.1.2.4 MLP Debris Near LSRB at Liftoff *(Camera E-26)*

A small dark piece of debris (possibly SRB flame duct debris) was noted traveling south between the LSRB and the FSS at 13:07:22.623 UTC. The debris was first seen to the north of the SLV and traveled in an arch towards the Orbiter. The debris was not noted in any other cameras to allow a phototheodolite analysis of the trajectory and velocity, but did not appear to be in the vicinity of the Orbiter when the debris exited the field of view. No further analysis was completed.

2.1.2.5 Debris Near LO2 Feedline
(Cameras E-65, E-79)

Figure 2.1.2.5 Debris from LO2 Feedline Joint

A white piece of debris (probably ice, approximately 3 inches in length) appeared to originate from the joint on the LO2 feedline near the forward bipod (see Figure 2.1.2.4) and fall along the LO2 feedline during liftoff on camera E-65. A smaller piece of debris was seen falling along the LO2 feedline at a lower location during liftoff on camera E-79. Neither debris item was seen to contact the vehicle.

2.1.2.6 Debris Falls along North Side of ET
(Camera E-4)

Two small white pieces of debris were noted falling along the north side of the ET (the side opposite of the Orbiter) at liftoff. These debris pieces might have originated from the GUCP area.

2.1.3 Debris after Liftoff

2.1.3.1 RCS Paper and Baggie Material Debris
(Cameras E-34, E-35, E-40, E-52, E-54, E-59, E-65, E-207, E-212, E-218, E-222, E-223, E-224, OTV-149, OTV-161, OTV-170, KTV-21B)

Multiple pieces of debris were seen falling aft of the Shuttle Launch Vehicle (SLV) at liftoff, throughout the roll maneuver, and beyond on the launch tracking views. Most of the debris sightings were probably reaction control system (RCS) paper or ice from the ET/Orbiter umbilicals. On the E-223 tracking camera view, RCS paper debris was seen to originate from the F2R and F4R RCS nozzles. None of the debris detected after liftoff was observed to strike the vehicle. No follow-up action has been requested.

2.1.3.2 Debris Near Left Wing at 15.6 Seconds MET
(Cameras E-52, E-222, KTV-21B)

A light colored piece of debris fell along the body flap and aft into the SSME plume at approximately 15.6 seconds MET (13:07:37.576 UTC). This does not appear to be RCS paper debris. The debris was first noted near the inboard aft trailing edge of the left wing on the camera E-222 film. The debris was first seen near the LH2 TSM disconnect area on camera E-52.

2.1.3.3 Multiple Pieces of Debris at 17 Seconds MET
(Camera E-59)

Multiple pieces of small light colored debris were noted on the ET side of the RSRB plume at approximately 17 seconds MET (13:07:39.244 UTC).

2.1.3.4 Debris Reported by Crew *(Task #10)*

Shortly after launch, the crew was asked to give a report of any debris they noted during launch and ascent. Commander Ronald Grabe reported that the windows were clean. He also reported that detection of debris was made difficult by the sun position relative to the Orbiter.

2.2 MLP Events

2.2.1 Orange Vapor (Possibly Free-burning Hydrogen)
(Cameras E-2, E-19, E-20, OTV-163, OTV-170, OTV-171)

Orange vapor, possibly free burning hydrogen, was noted below the SSMEs near the left OMS nozzle and also north of the body flap at SSME ignition. Orange vapor was noted above the SSME #1 nozzle at 13:07:18.429 UTC on camera E-2. This phenomenon has been noted on many previous missions.

2.2.2 Green Vapor Near Left OMS Nozzle
(Camera OTV-171)

A greenish vapor was noted between SSME #1 and SSME #2 near the left OMS nozzle during SSME ignition. This phenomenon has been noted on previous missions.

2.3.2 Light Colored Streak in SSME Plume
(Cameras ET-204, ET-212)

Figure 2.3.2 **Light Colored Streak in SSME plume at 38 seconds MET and Reference Image**

A light colored streak was noted in the SSME plume at approximately 38 seconds MET on ET-212. Figure 2.3.2 provides an image of the streak along with an image of an earlier time without the streak. A white puff (believed to be the same event seen from a different perspective) was noted at the same time and similar position on camera ET-204.

2.3.3 Flares in SSME Exhaust Plume
(Cameras E-207, E-212, E-222)

Multiple flares in the SSME exhaust plume were noted after the roll maneuver. The flares were seen at approximately 27.7, 33, 33.6, 36.2, and 36.3 seconds MET. Flares in the SSME exhaust plume have been seen on previous missions.

2.3.4 Body Flap Motion *(Task #4)*
(Camera E-207)

During ascent very slight body flap motion was noted on the E-207 tracking camera film. The magnitude of the motion seen on the STS-57 views was not sufficient to warrant further analysis.

2.3.5 Condensation Collar *(Task #12)*
(Cameras E-204, E-207, E-208, E-211, E-212, E-220, E-222, E-223, E-224, ET-204, ET-207, ET-208, ET-212, KTV-4B, KTV-5, KTV-13, KTV-21B)

Dick Thomas of RI-D noted while watching the national news coverage of the launch of STS-57 that there may have been excessive vapor clouds around the SLV during ascent and that this vapor might be related to a cause of payload bay door seal damage which has occurred on several flights (e.g. STS-41, STS-40). His concern was for pressure spikes that the payload bay may be experiencing and thought he might have seen an ingestion of air into the payload bay.

STS-57 video trackers were rescreened to see if there was any turbulence of the air around or entering into the payload bay doors at the seal areas. (The condensation occurred between mach 0.87 and mach 1.16.) The condensation collar in these views did not appear turbulent, however it was seen to pulse several times during ascent. (This event has been seen on several previous missions and is due to levels of moisture in the atmosphere that the SLV is traveling through.) There appeared to be no visible influx of air into the payload bay. The collar appeared to be separated from the Orbiter and did not actually touch the payload bay doors except at the forward end of the SLV where the condensation collar begins. The condensation also appeared to originate from the edges of the wings, OMS pods, and the vertical stabilizer. This phenomenon has also been seen on previous missions and does not appear out of the ordinary.

STS-40 video tracking views were also reviewed since this was the mission that had significant payload bay door seal damage. The analysis of these views was hampered due to numerous clouds in the area during ascent. In the areas where the collar was visible, the condensation was comparable to that of STS-57 in amount and shape and did not appear turbulent.

2.3.6 Linear Optical Effect
(Cameras E-212, ET-212)

A linear optical distortion along the aft portion of the SLV was noted at 13:08:15.851 UTC on the ET-212 long range video tracking view. Linear optical effects have been seen on previous mission long range tracking views. No follow up action is planned.

2.3.7 Recirculation *(Task #1)*
(Cameras ET-204, ET-208, KTV-13, E-204, E-208, E-212)

The recirculation or expansion of burning gases at the aft end of the SLV prior to SRB separation has been seen on nearly all previous missions. For STS-57, the start of recirculation was observed at about 92 seconds MET on KTV-13 and the end was noted at approximately 115 seconds MET on Camera ET-204. See Appendix D, Task #1 for a summary of recirculation start and stop times for all missions since reflight.

after ET separation while the ET was at a distance of 933 meters from the Orbiter. The last photograph was taken at 11 minutes and 55 seconds after ET separation while the Orbiter was 2,234 meters from the Orbiter. At the start of photography, the ET tumbled at 2.2 degrees per second. The analysis results were reported to the Mission Evaluation Room (MER) Manager and to the standard distribution. The results of this analysis are located in Appendix D, Task #6.

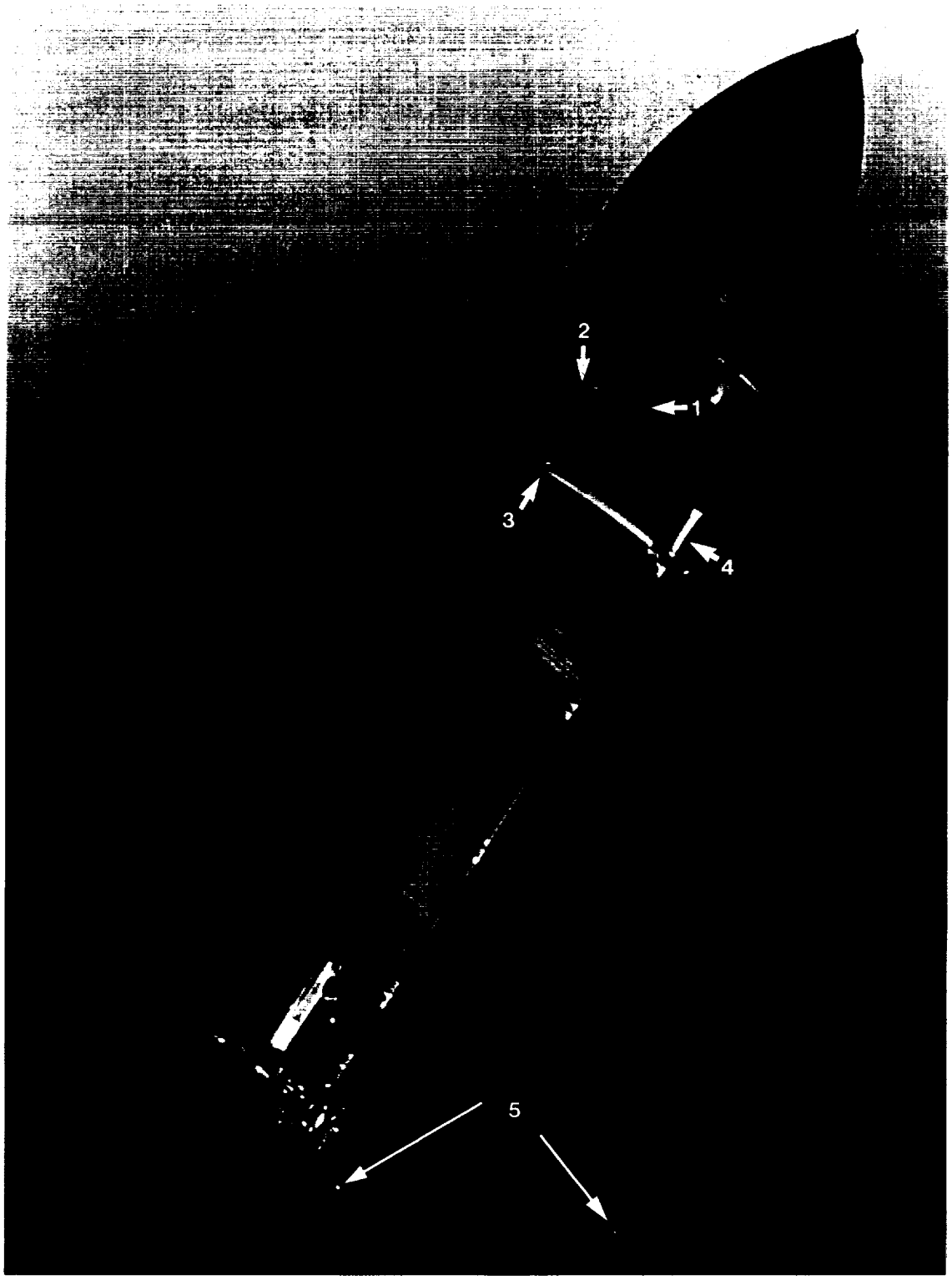


Figure 2.4.2 Onboard Handheld Camera View of the ET

Nine to ten divots were visible on the ET intertank TPS acreage to the right of the forward LSRB attach point (1). Five divots were visible on the LH2 intertank between the ET access door and the LSRB forward attach point (2). Two large divots were seen

on the lower LH2 intertank interface. One was located below the LSRB forward attach point (3) and the other was on the -Z side of the ET. Multiple divots were seen near the ET/Orbiter attach bipod (4). Pieces of white debris were visible in the background on many of the frames (5).

A divot was visible on the aft vertical thrust strut near the ET LO2 umbilical. This damage is being worked as part of the divot problem reported on the STS-56 ET (inflight anomaly number STS-56-T-001). The area surrounding the strut is more clearly visible from 35 mm umbilical well camera (see Section 2.4.4).

A single large divot on the LH2 intertank interface below the ET access door (-Z side) measured 12 inches and a single large divot below the LSRB forward attach point (-Y side) measured 19 inches. The 9 divots to the right of the LSRB forward attach point were measured to range between 6 and 7 inches. The ET/Orbiter separation velocity was determined to be 3.74 meters per second which is slightly less than that seen on recent missions.

2.4.3 16 mm Umbilical Well Camera Views of the SRB and ET Separation *(Task #5)*

The 16 mm motion picture film taken from the Orbiter LH2 umbilical was reviewed. The focal length of the camera lens was 5 mm. This 16 mm motion picture film showed LSRB and ET separation along with the normal venting and debris associated with these events.

The 16 mm film sequence of the LSRB separation has good exposure and focus. Multiple pieces of light colored TPS debris of various shapes and sizes are visible before, during, and after the separation of the SRBs. Chipping and erosion of the TPS on the base of the electrical cable tray and the aft ET/Orbiter and ET/LSRB attach struts are visible. A piece of insulation on the base of the electrical cable tray was seen to detach prior to SRB separation. The loose end of this insulation eventually broke off and fell from view. The LSRB separation appeared normal. A dark piece of debris was visible on the ET side of the LSRB/ET attach just after SRB separation. There were three bright marks or reflections visible on the LSRB attach on the face exposed after the LSRB detached from the external tank.

The initial exposure of the 16 mm film during the second film segment of the separation of the external tank was very dark because the sun was behind the ET. The view improved during the umbilical well purge. Multiple pieces of white debris (ice/frost) and white vapors were in view. After the umbilical purge, the white debris continued to be in view although the view was again very dark. Periodically, orange or light colored vapors come into view that were probably caused by RCS firings.

Figure 2.4.3a 16 mm Camera View of the ET LH2 Umbilical

After the external tank separated from the Orbiter, a piece of loose insulation or foam was visible on the view of the inboard side of the ET LH2 umbilical. This piece of foam was over 20 inches long and 4 inches wide as determined by comparison to known structures on the face of the LH2 umbilical (1). Two possible pieces of detached white RTV were visible on the inboard and forward sides of the LH2 umbilical (2). A segment of the red RTV seal that surrounds the outer border of the LH2 umbilical appeared to be missing near the four inch line connect (3). The large circle of ice in the LH2 seventeen inch line orifice is an expected occurrence and has been seen on the previous mission umbilical well films (4).

A slender piece of white debris that appeared to be flexing was visible on the left side of the film view of the ET LH2 umbilical after ET separation. This may be a piece of white RTV that came from the LH2 umbilical.

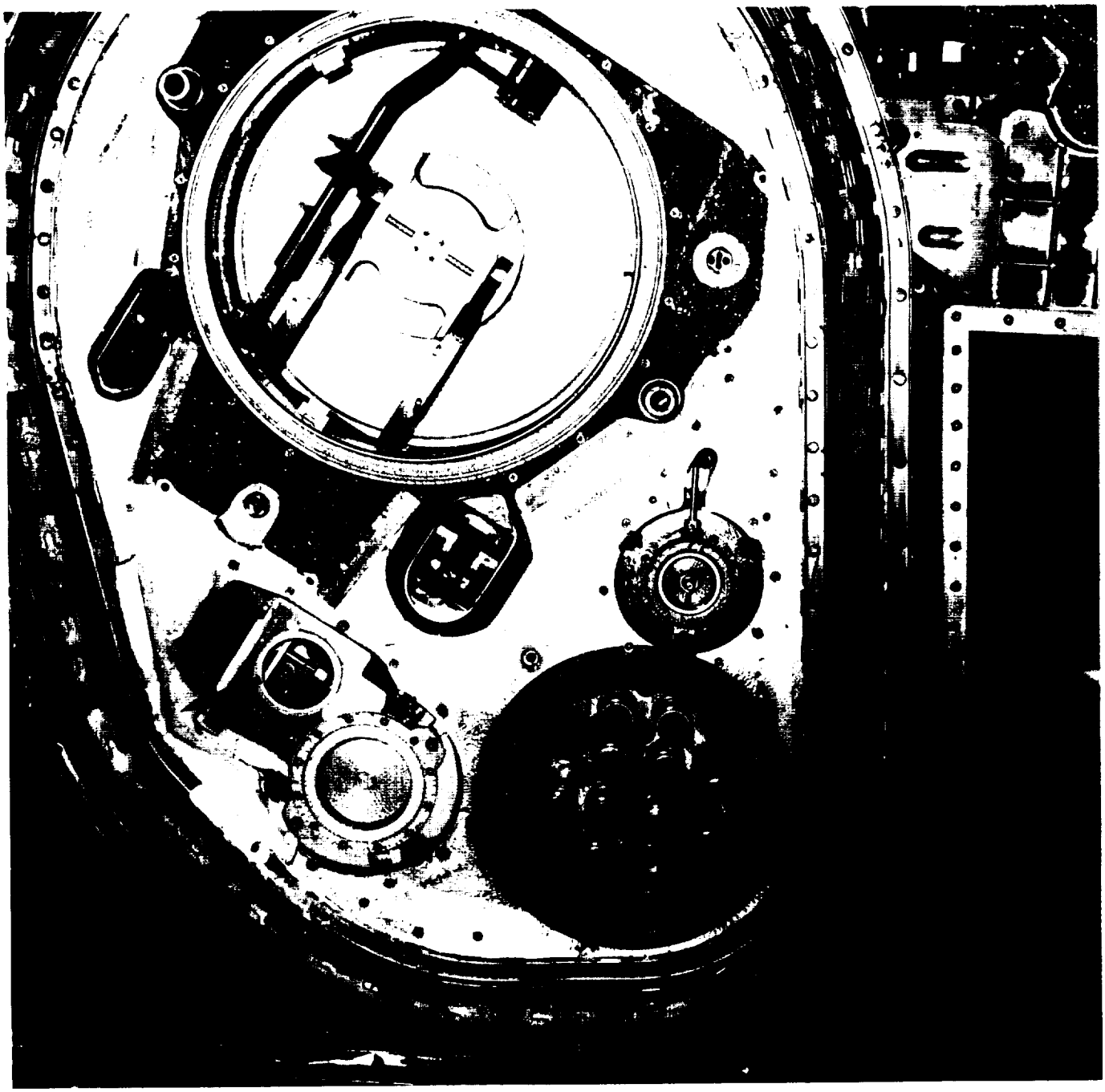


Figure 2.4.3b **Closeout Picture of the LH2 Umbilical taken by the KSC Debris Team**

A picture of the Orbiter LH2 umbilical (Figure 2.4.3b) taken by the KSC Debris Team after landing indicated that approximately 10 inches of foam material remained near the four inch line connect. The 16 mm umbilical well camera film of the ET LH2 anomalies was shown to the JSC Propulsion and Power Division/EP2 engineers. The JSC engineers suggested that the closeout foam placed near the four inch line connect prior to launch

may be sticking causing some of the RTV and foam to be pulled loose during ET separation.

Very small pieces of debris were noted inside the umbilical well camera housing. Pieces of white debris continued to move across the field of view until the end of the film. The ET had a slight lean to the right by the end of the film.

Poor imagery due to the back lighting from the sun significantly hindered analysis. The detailed screening sheets are located in Appendix D, Task #5.

2.4.4 35 mm Umbilical Well Camera Views of the ET Separation *(Task #5)*

Sixty-four well focused 35 mm frames were obtained of the external tank separation. The first six frames were too dark for analysis because the sunlight was blocked by the external tank. Frames 7 through 27 were dark but usable. A lens flare hampered analysis after the twenty-seventh frame. The 35 mm umbilical camera screening sheets are located in Appendix D, Task #5.

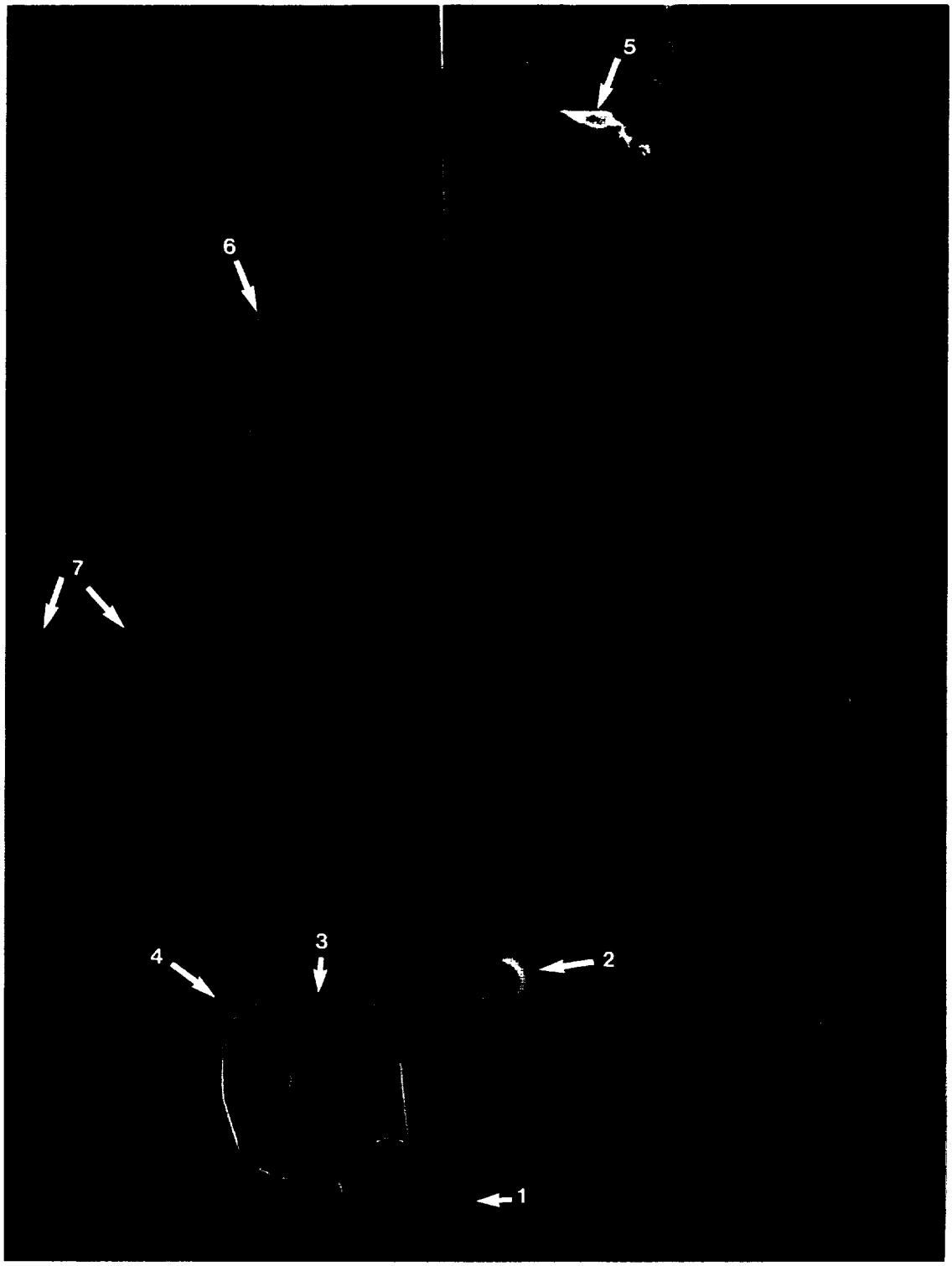


Figure 2.4.4a 35 mm Camera View of the ET LO2 Umbilical

TPS erosion was visible on the right side of the LO2 umbilical (1). A red seal around the EO-3 fitting above the LO2 umbilical was detached (2). The lightning contact strip at the

forward end of the LO2 umbilical appeared to be missing (3). JSC engineers were consulted and according to their information the electric contact strip was present prior to launch. Possible TPS damage or a piece of loose insulation was visible near the upper left corner of the LO2 umbilical (4). This possible loose insulation may be related to a three inch piece of ET foam that was found during the post landing inspection of the Orbiter LO2 umbilical by the debris inspection team. This three inch piece of foam adhered to a tile on the LO2 door near the hinge line according to the post landing inspection team report. A section of TPS was missing from the forward end of the ET aft +Y LO2 vertical thrust strut (5). The missing TPS appeared to have left a deep divot. A primed or bare metal surface was visible at the center of the missing TPS area. An engineer at MSFC stated that the missing TPS is being worked as part of the divot problem reported on the STS-56 external tank (inflight anomaly number STS-56-T-001). TPS erosion was visible on a aft bracket over the LO2 feedline at approximately station 1958 (6). Small, white marks were visible on the TPS to the left of the LO2 feedline at the base of the LH2 tank (7).

Figure 2.4.4b **35 mm Camera View of the Bipod and LH2 Tank/Intertank Region of the External Tank**

Multiple pieces of white debris were imaged between the camera and the external tank. The white debris appeared to be ice (1). Multiple white "popcorn" marks were visible on the intertank stringers forward of the bipod (2). Several small white marks or divots were visible between the bipod legs on the LH2 tank/intertank closeout flange (3). Two divots less than six inches in size were visible on the intertank closeout flange to the right of the

LO2 feedline (+Y axis) (4). One divot less than six inches in size was visible on the LH2 tank TPS just below the intertank/LH2 tank closeout flange on the +Y axis (5).

2.5 On Orbit Events

No on orbit events were requested to be analyzed this mission

2.6 Landing Events

2.6.1 Landing Sink Rate from Video *(Task #3)* *(Camera KTV-33)*

Camera TV-33 was used to determine the video nose gear and main gear sink rate for STS-57. For both the main gear sink rate and the nose gear sink rate, a known length of Orbiter black tile was used as the scalar reference. This scalar reference was 78 inches in length. After the distance values were determined and scaled, a trend of these distances was calculated to smooth the data and determine the sink rate from the slope of the data.

Left main gear sink rate was determined to be 19.9 inches per second or 1.7 feet per second and the right main gear sink rate was determined to be 17.5 inches per second or 1.5 feet per second.

Nose gear sink rate was determined to be 1.2 feet per second, which is consistent with the film analysis.

Graphs depicting the above data can be seen in Appendix D, Task #3.

2.6.2 Landing Sink Rate Analysis Using Film *(Task #3)* *(Cameras EL-9, EL-12)*

Camera EL-9 film viewing the aft end of the Orbiter was used to determine the sink rate of the main gear. The good view provided by this camera allowed the observation that both inboard tires contacted the runway surface prior to the respective outboard tires. The left inboard tire (44.5 inches) was used to scale the measurements. Data was gathered for 1.019 seconds prior to landing through touchdown. The motion of the wheel was measured and a linear regression was applied on this normalized vertical distance versus time data to find the actual rate. The main gear sink rate was determined to be 1.6 feet per second which is well within the current threshold limits.

Nose gear touchdown occurred approximately 18 seconds after main gear touchdown. Camera EL-12 viewing the left side of the Orbiter near the point of nose gear touchdown was used to scale the measurements. Data was gathered for the 1.967 seconds prior to nose gear touchdown. The distance between the nose wheel and the runway surface was computed and a linear regression was applied on this normalized vertical distance versus time data to find the actual rate. The nose gear sink rate was determined to be 1.7 feet per second.

Graphs depicting the above data can be seen in Appendix D, Task #3.

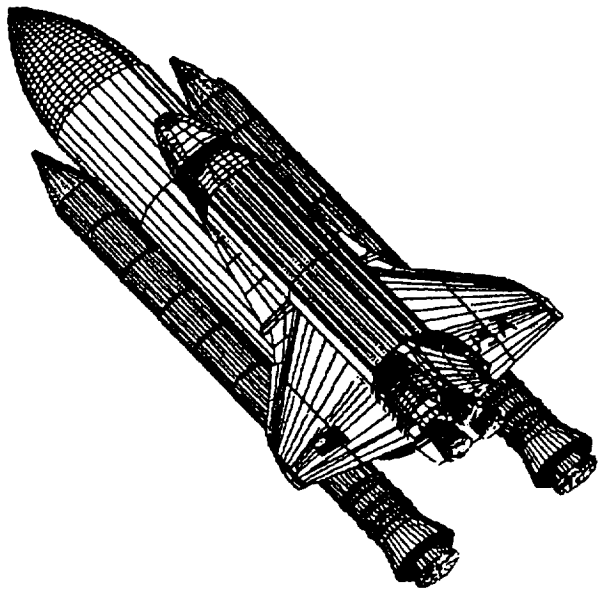
NASA
National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

SPACE SHUTTLE

ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT

STS-57



STS-57 ENGINEERING PHOTOGRAPHIC ANALYSIS REPORT

TABLE OF CONTENTS

* Photographs in the individual camera assessments are representative photographs and are not necessarily photographs taken from this particular launch.

CAMERA DATA RECEIVED FOR STS-57

	16mm	35mm	Video
MLP	22	0	4
FSS	7	0	3
Perimeter	3	4	6
Tracking	0	13	11
Onboard	3	2	0
Totals	35	19	24

A detailed individual motion picture camera assessment is provided as Appendix B. Appendix C contains detailed assessments of the video products received at MSFC.

a. Ground Camera Coverage:

Photographic coverage of STS-57 was considered good. Tracking camera coverage was degraded due to cloud cover and atmospheric conditions. Cameras E-54 and E-213 provided no data and were not shipped to MSFC. Camera E-57 did not operate due to a mechanical failure. Timing information on camera E-3 was invalid. Timing data was lost on cameras E-1 and E-4 after approximately T+6 seconds.

b. Onboard Camera Assessment:

A camera was flown on each SRB forward skirt to record the main parachute deployment. Both cameras operated properly but ran out of film prior to water impact. The astronauts carried a 35mm hand-held camera to record film for evaluating the ET TPS integrity after ET separation. Thirty-seven frames of data were recorded. A 35mm camera was mounted in the right umbilical well to record ET separation and ET TPS integrity. Sixty-four frames of data were recorded. A 16mm motion picture camera was mounted in the left umbilical well to record during and after SRB and ET separation.

IV. ANOMALIES/OBSERVATIONS:

a. General Observations:

While viewing the film, several events were noted which occur on most missions. These included: pad debris rising and falling as the vehicle lifts off; debris induced streaks in the

c. SRB Separation Time:

SRB separation time for STS-57 was determined to be 172:13:09:26.78 UTC as recorded by camera E-207.

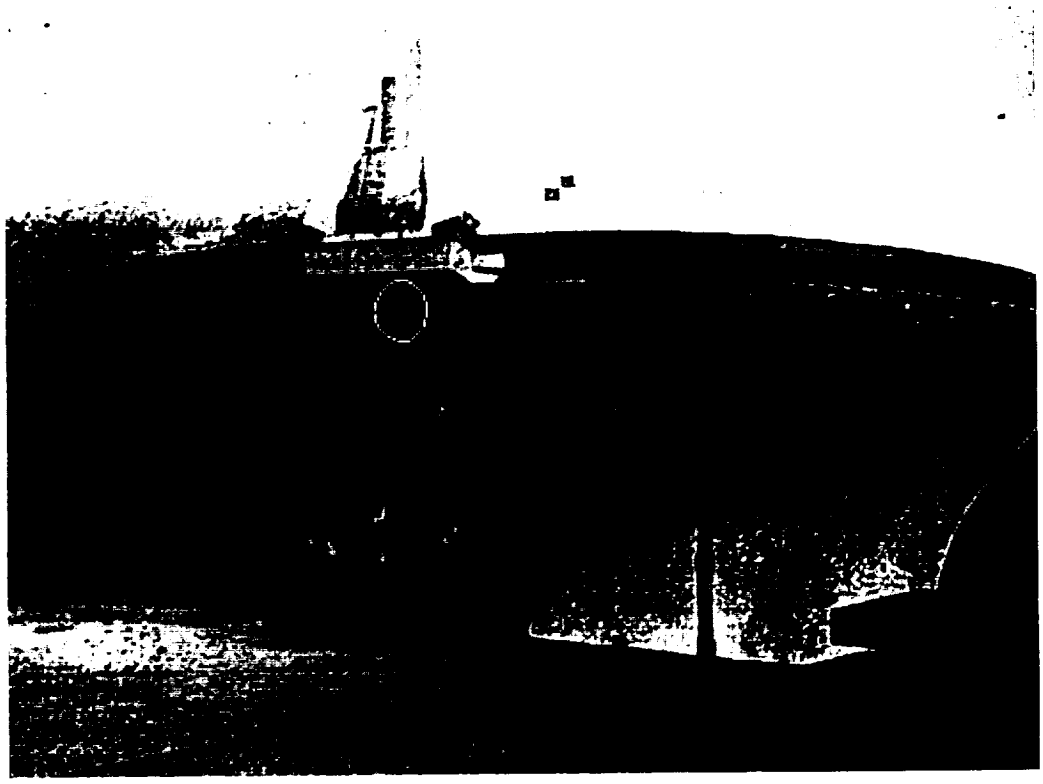


Figure 1.

Frangible nut material from holddown post M-2.

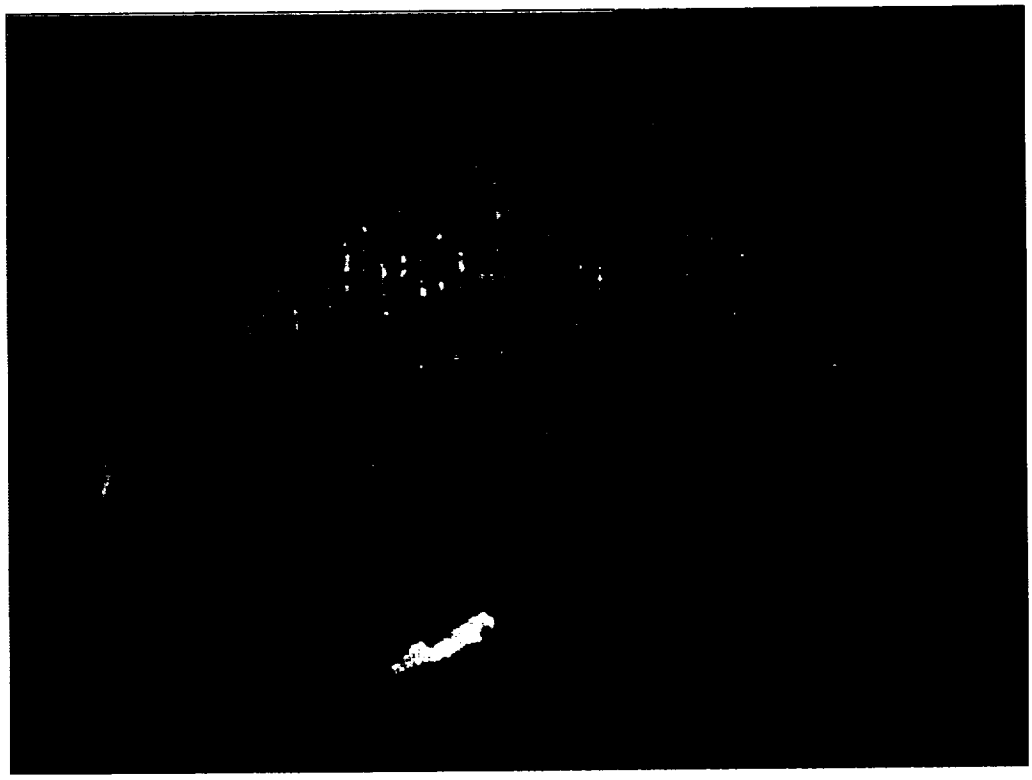


Figure 2.

Popcorning of TPS near bipod strut and large divot on LH2 tank.

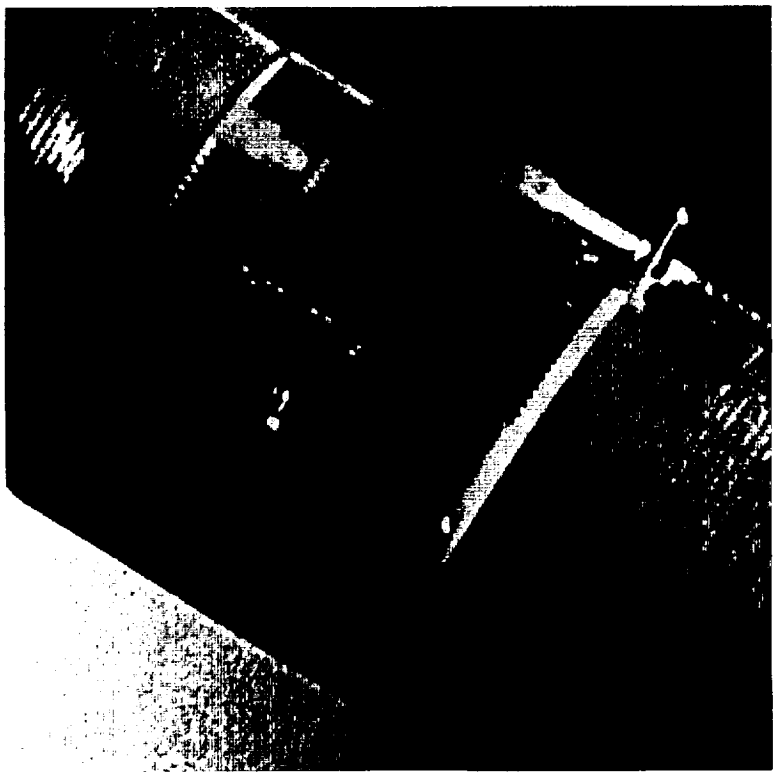


Figure 3.

Divots on intertank near left SRB attach point.

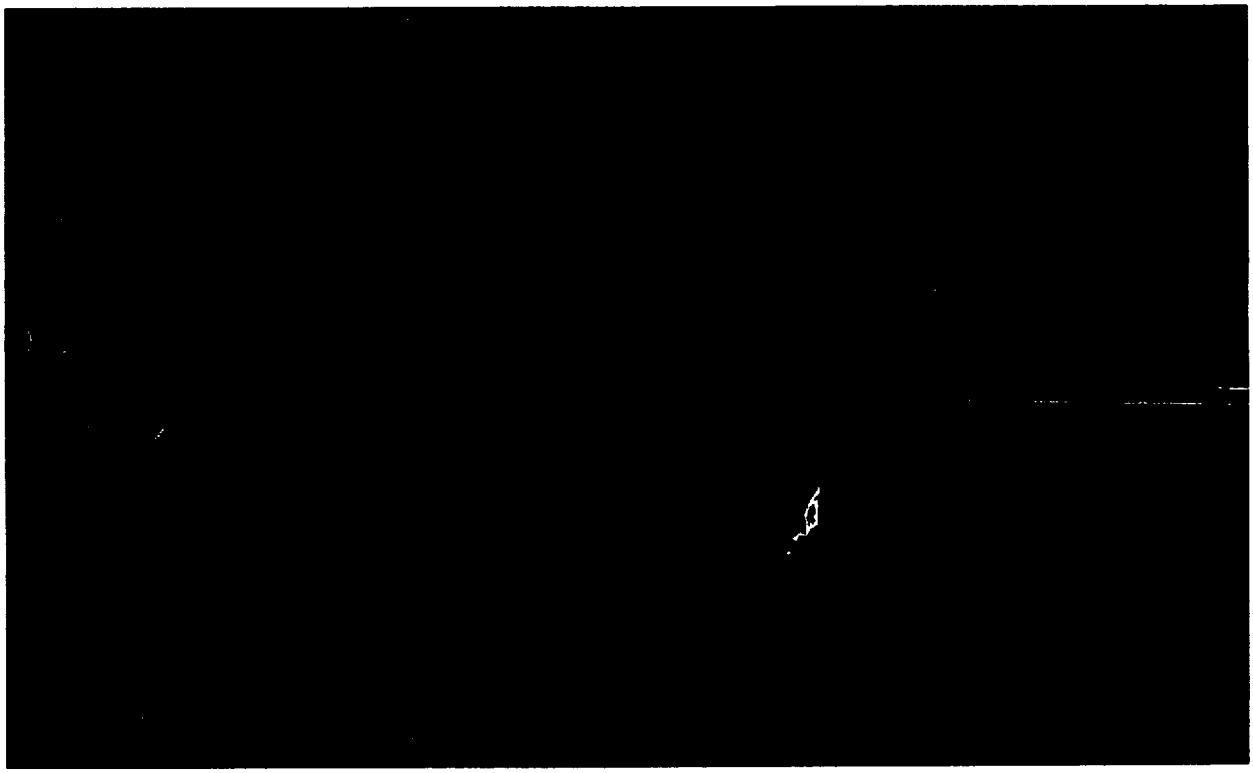


Figure 4.

Divots on thrust strut.

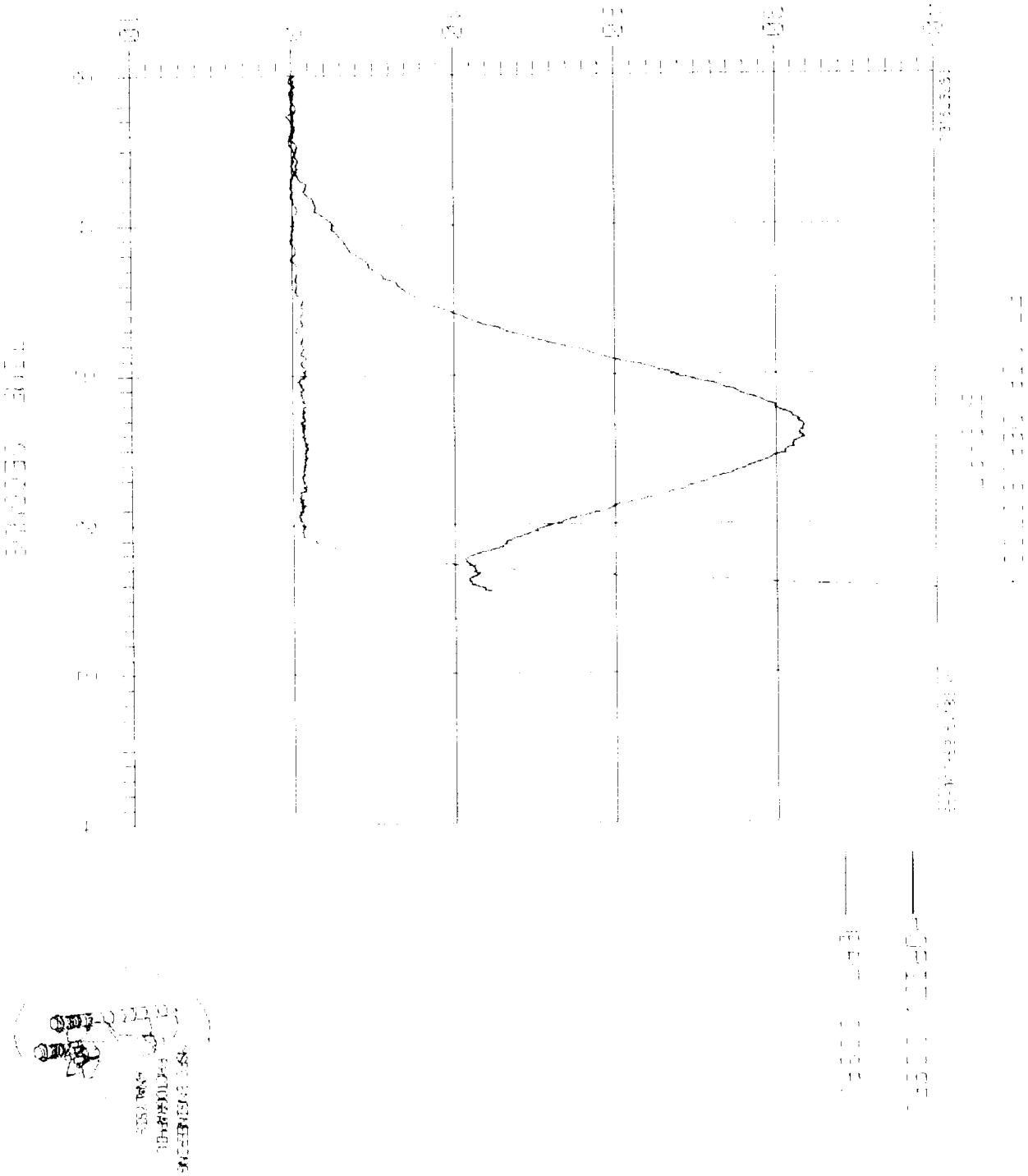


Figure 5

Appendix C. Rockwell Photographic Analysis Summary

Space Systems Division
Rockwell International Corporation
12214 Lakewood Boulevard
Downey, California 90241

Rockwell International

August 2, 1993

In Reply Refer to 93MA2128

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

Attention: L. G. Williams (WA)

Contract NAS9-18500, System Integration, Transmittal of the Rockwell Engineering Photographic Analysis Report for the STS-57 Mission.

The System Integration Contractor hereby submits the Engineering Photographic Analysis Summary Report in accordance with the Space Shuttle Program Launch and Landing Photographic Engineering Evaluation Document (NSTS 08244).

Extensive photographic and video coverage was provided and has been evaluated to determine ground and flight performance. Cameras (cine and video) providing this coverage are located on the Launch Complex 39B Fixed Service Structure (FSS), Mobile Launch Platform (MLP), various perimeter sites, and uprange and downrange tracking sites for the STS-57 launch conducted on June 21, 1993, at approximately 6:07 a.m. (PDT) from the Kennedy Space Center (KSC) and for the landing on July 1, 1993 at KSC at 5:52 a.m. (PDT).

Rockwell received launch films from 82 cameras (58 cine, 24 video) and landing films from 24 cameras (14 cine, 10 video) to support the STS-57 photographic evaluation effort. Three films, E54, E57 and E213 were not available due to camera malfunction.

All ground cameras coverage for this mission including coverage on the MLP, FSS and tracking cameras were good, however, the tracking film cameras and videos was hampered by clouds.

Overall, the films showed STS-57 to be a clean flight. Several pieces of ice from the ET/ORB umbilicals were shaken loose at SSME ignition, but no damage to the Orbiter Thermal Protection System (TPS) was apparent. The usual condensation and water vapors were seen at the ET aft dome and the SRB stiffener rings and dissipated after the completion of the roll maneuver.

(Packing Sheet No. DM93-15214)

2. Review of the 35mm Umbilical Well camera views of the ET separation shows possible TPS damage or a piece of loose insulation near the upper left corner of the LO_2 umbilical. This possible loose insulation may be related to the three inch piece of ET foam that was found during the post landing inspection of the Orbiter LO_2 umbilical by the debris inspection team. No additional follow on work is scheduled for this issue.

   On the 16mm LH_2 Umbilical Well Camera film of the SRB and ET separation a piece of loose insulation or foam was noted on the inboard side of the ET LH_2 umbilical and possibly two pieces of detached white RTV are visible on the inboard sides of the LH_2 umbilical. Also, a piece of red RTV seal around the outer border of the LH_2 umbilical appears to be missing near the four inch line connect. JSC and RI/DNY engineers suggested that this may be caused by the close out foam placed near the four inch line connect, prior to launch, sticking and pulling some of the RTV and foam loose during ET separation. No follow on work is planned.

3. On cameras E-2, E-3, E-19 and E-20, a white flash was noted in the SSME #1 plume at liftoff. Flashes have been observed on previous missions and are probably caused by small amounts of contaminants in the main engine. No follow-up action is planned.

4. Orange vapor (possibly free burning hydrogen) was seen below the SSME's and the body flap just prior to SSME ignition on cameras (OTV-163, OTV-170, OTV-171, E-2, E-19 and E-20. This vapor appears to be similar to the vapor noted on previous missions. It is not an issue and no follow-up action is planned.

5. On camera E-8, a metallic appearing piece of debris was noted falling from the DCS stud hole of the right SRB holddown post M-2 at liftoff. This debris did not appear to strike the vehicle. No follow-up action is planned.

6. On cameras E-42 and E-50, the GH_2 Vent Arm retraction lanyard did not reel in and was slack. No follow-up film analysis action is planned.

7. Multiple pieces of debris particles were seen falling aft of the Orbiter during and after completion of the roll maneuver on cameras E-212, E-218, E-222, and E-223. The debris was probably RCS paper covers or ice from the ET/Orbiter umbilicals. No follow-up action is planned.

8. Flares and flashes seen in the SSME exhaust plume (E-207, E-212, E-222) during ascent. These observations have been seen in the SSME plumes on previous missions and are understood to be burning of propellant impurities including RCS paper covers. No follow-up action is planned.

12. The landing of STS-57 occurred on runway 33 at the KSC Shuttle Landing Facility. Good video and film coverage were obtained and no anomalous events were observed. The flight marked the ninth use of the Orbiter drag chute. The drag parachute system performed as expected. All sequenced events occurred as expected and no hardware anomalies were observed.

    During the post-landing inspection slight tile damage on the base of the vertical stabilizer stinger above the door for the drag chute was noted. No follow-up action has been requested.

This letter is of particular interest to Messers W. J. Gaylor (VF2) and C. F. Martin (MK-SIO-2) at NASA/JSC and NASA/KSC respectively. The Integration Contractor contact is R. Ramon at (310) 922-3679.

ROCKWELL INTERNATIONAL
Space Systems Division

J. A. Wolfelt
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13. ABSTRACT *(Maximum 200 words)*

A Debris/Ice/Thermal Protection System (TPS) assessment and integrated photographic analysis was conducted for Shuttle mission STS-57. Debris inspections of the flight elements and launch pad were performed before and after launch. Ice/frost conditions on the External Tank were assessed by the use of computer programs, nomographs, and infrared scanner data during cryogenic loading of the vehicle followed by on-pad visual inspection. High speed photography was analyzed after launch to identify ice/debris sources and evaluate potential vehicle damage and/or in-flight anomalies. This report documents the debris/ice/TPS conditions and integrated photographic analysis of Shuttle mission STS-57, and the resulting effect on the Space Shuttle Program.

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